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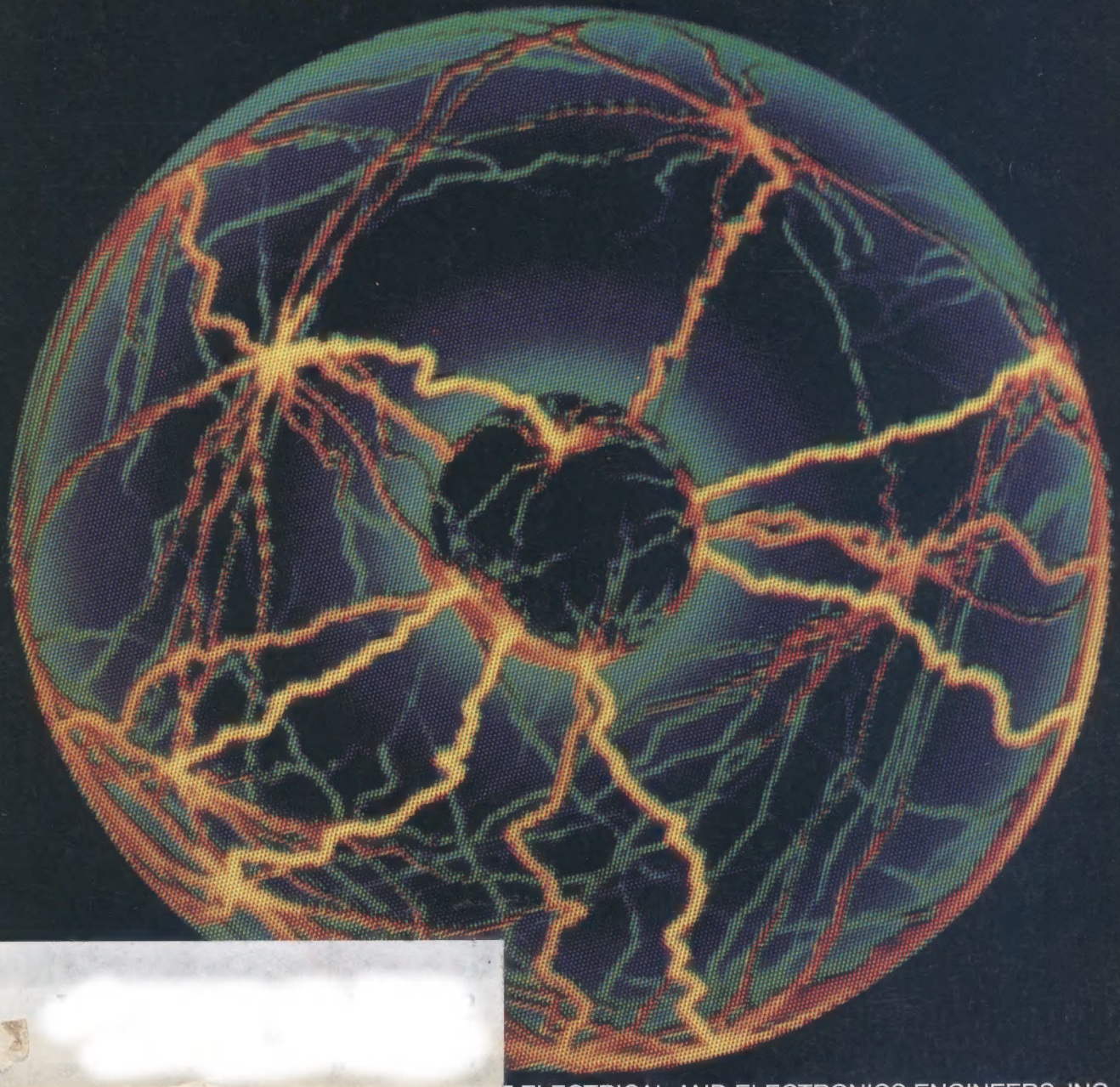

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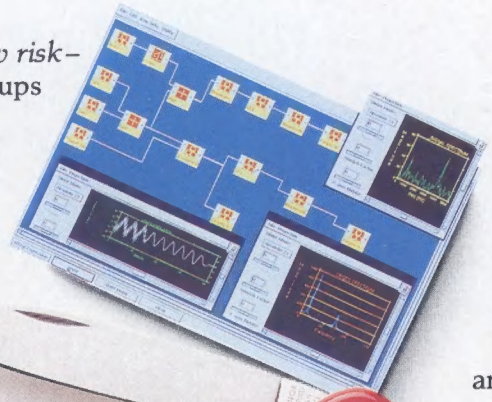

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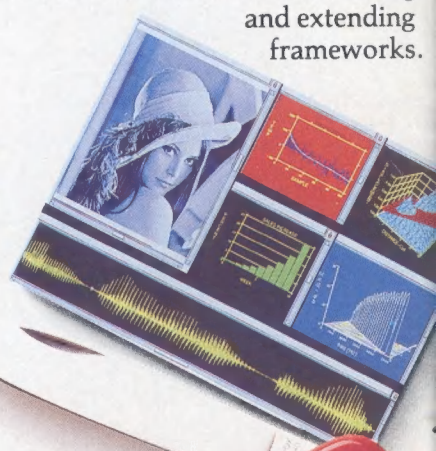

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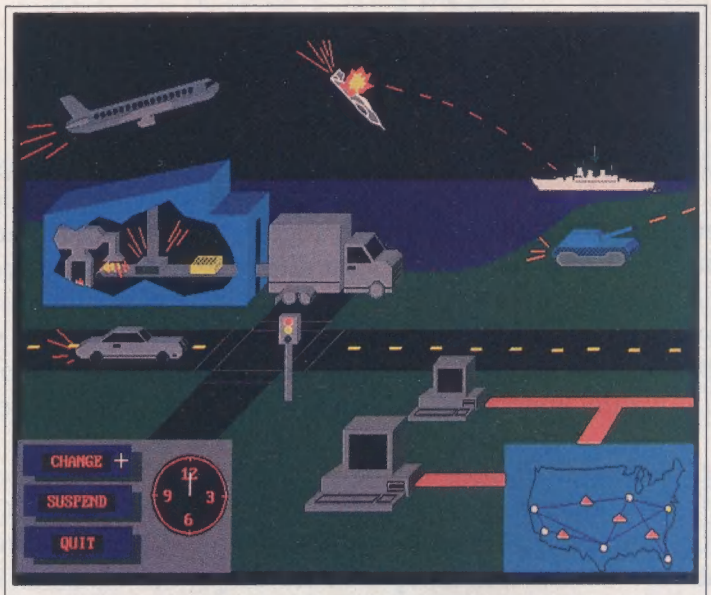

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Hughes Aircraft Company's commitment to cost reduction coupled with quality improvement helps save more than $1 million in a communications satellite program. The commitment involves constantly monitoring and measuring all phases of a program with an eye toward improving quality and reducing costs. In the HS 601 communications satellite program, Hughes recognized substantial savings by replacing time-consuming structural bonds with inexpensive aluminum clips. Other savings were achieved by replacing detailed inspection of incoming parts with verification of only the critical parameters, and by determining which departments needed to sign off on individual engineering drawings, eliminating unnecessary reviews by unaffected departments.

The F/A-18 Hornet has surpassed one million lifetime flight hours. This milestone reflects the F/A-18's utility, flexibility, and readiness, which is partly due to its reliable APG-65 radar, built by Hughes. The "one million" milestone combines flying hours for all the McDonnell Douglas-built F/A-18s, including operations with the U.S. Navy, Marine Corps, the Canadian Forces, Royal Australian Air Force, Spanish Air Force, and NASA's high-angle-attack research. Currently 900 planes use the APG-65 radar systems. The historic flight took place during operations from the aircraft carrier USS Eisenhower in the Mediterranean Sea.

The first transfer of missile technology between Hughes and Japan has been achieved, as 32 Hydra-70 rocket launchers have rolled off an assembly line in Japan. These production units will be mounted on the Japanese Ground Self-Defense Forces' AH-1S Cobra helicopter fleet. Hughes developed the launchers and delivered the initial 75 to Japan. The launchers are the first products to come from Hughes' 1988 manufacturing agreement with Minebea Ltd. of Tokyo.

A new solid-state broadband transmitter operates at considerably lower cost and reduced power consumption, while having performance equivalent to a 200-watt "brute force" system. This HIBT-118 — the latest in the Hughes family of AML® solid-state broadband transmitters — uses high-power FET amplifiers and unique microwave circuitry to achieve state-of-the-art performance in solid-state equipment. The inherent flexibility associated with its broadband 1-to-80 channel design, plus its increased power, provides for supertrunking applications well in excess of 20 miles.

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Newslog

AUG 15. Researchers at **IBM Corp.'s Almaden Research Center,** San Jose, Calif., said they had created the smallest electronic switch in existence, one that depends on the motion of a single atom. The discovery was made using IBM's scanning tunneling microscope, which can also manipulate single atoms.

AUG 15. The **U.S. International Trade Commission,** Washington, D.C., cleared the way for 63 percent antidumping duties on Japanese shipments of active-matrix liquid crystal displays. The ruling was a victory for seven small display makers that fought not only the Japanese electronics giants, but also IBM, Apple Computer, Compaq Computer, and Tandy.

AUG 28. 3M, St. Paul, Minn., said it had developed the first blue-green laser from a semiconductor source. The prototype device, having a shorter wavelength than red and infrared lasers, could triple or quadruple the amount of data stored on optical discs and enhance laser imaging in medical diagnostics.

AUG 28. Three California utilities said they will build what may possibly be the first economically viable solar energy plant to an advanced design. The companies—**Southern California Edison Co., Los Angeles Department of Water and Power,** and **Sacramento Municipal Utility District**—said the US $39 million, 10-MW plant in the Mojave desert will use giant mirrors to focus the sun's rays on salt, and heat from the molten salt would be used to convert water to steam to drive a turbine generator. The U.S. Department of Energy will pay half the cost.

AUG 30. Texas Instruments Inc., Dallas, and three Japanese electronics giants—**Fujitsu Ltd., Hitachi Ltd.,** and **Sony Corp.**—said they would jointly develop semiconductors for high-definition television sets sold in Japan. To reduce the sets' price, now US $30 000, the companies will drastically simplify the TV decoders by combining the functions of several chips into single chips.

SEP 6. Inmos Ltd., the UK-based semiconductor manufacturer, said it has secured exclusive rights to manufacture and market **IBM Corp.'s** new chips for generating PC graphics. Inmos, owned by **SGS-Thomson,** the Italian-French semiconductor group, will sell sets of extended graphics array (XGA) chips to other manufacturers to help establish the chips as the worldwide standard.

SEP 11. The **U.S. Senate** unanimously passed a measure authorizing the expenditure of US $1 billion over five years on developing a high-speed supercomputing network that would link Federal research centers, universities, and corporations. The network will be 100 times faster than current technology.

SEP 12. Applied Materials Inc., Santa Clara, Calif.—one of the few remaining U.S. makers of semiconductor manufacturing equipment—announced plans to produce semiconductor manufacturing equipment for thin-film-transistor liquid-crystal display screens. The new machine's potential customers are in Japan, where most of the world's flat-panel displays are made.

SEP 13. Inmarsat, the London-based international satellite consortium, announced plans to launch 30–40 small satellites around the globe to relay calls from pocket-sized wireless telephones to each other and to conventional telephone networks anywhere on earth.

SEP 15. The Upper Atmosphere Research Satellite (UARS), at 6500 kg the largest environmental satellite ever built, was launched into orbit 600 km above the earth from the U.S. space shuttle Discovery.

SEP 16. Groupe Bull SA of France, **Siemens AG** of Germany, and **Ing. C. Olivetti & Cie SpA** of Italy said they have started designing a multimillion-dollar computer network that will span Europe. The companies are seeking to convince the European Commission that they can work together effectively. Collaboration on a project of this scale is unprecedented among European companies.

SEP 18. Richmond, a London borough, said it would test the first public electronic road-pricing system in Europe. The goal of charging drivers on its roads on a pay-as-you-drive basis is to curb traffic growth in an area where no further roads can be built. The system, called Timezone, was developed by **Britain's GEC-Marconi.**

SEP 23. IBM Corp. and **Thinking Machines Corp.,** Cambridge, Mass., said they had signed an agreement to explore the integration of Thinking Machines' massively parallel computing systems technology with IBM's mainframes. The pact also gives Thinking Machines access to IBM's advanced semiconductor and disk drive technology.

SEP 24. Motorola Inc., Schaumburg, Ill., said it would offer a new radio-transmission technology that triples the capacity of a cellular telephone network. Called Narrow-Band Advanced Mobile Phone Service, the system splits a standard cellular channel into three, allowing it to be incorporated into existing transmitters and receivers. The technology increases the capacity of cellular services more cheaply than by switching to new digital transmission technologies.

SEP 24. Toshiba Corp., Tokyo, said it would immediately cease producing its most advanced active-matrix–display computers at its U.S. subsidiary's plant in Irvine, Calif., and move its assembly operations back to Japan. Analysts said the move, expected to be copied by other Japanese manufacturers, was in retaliation for the 63 percent tariff the United States imposed in August on Japanese shipments of active-matrix screens.

OCT 3. Two Israeli scientists, **Adi Shamir** of Weizman Institute and **Eli Biham** of Technion, said they have developed a powerful mathematical technique that for the first time makes it possible under certain circumstances to break the Data Encryption Standard, the U.S. government system used by many businesses for encrypting highly sensitive information. Shamir said the approach is much faster than an earlier method in which a computer tests every possible key to unlock the code.

OCT 7. The **United States Court of Appeals,** Washington, D.C., gave the seven Bell operating companies permission to immediately begin providing information services—like electronic Yellow Pages, medical information services, and news services. The ruling overturns part of a lower court decision in July in which Federal District Judge Harold H. Greene said he would lift a longstanding ban on such services but also delayed doing so until opponents appealed.

Preview:
NOV 19–21. The **National Small Business Innovation Research Conference** is to be held in Detroit, Mich., to help small high-technology companies learn how to win Federal R&D awards and leverage these awards into commercially successful products. For information, contact Foresight Science and Technology, Delray Beach, Fla.; 407-274-4005.

COORDINATOR: Sally Cahur

NOVEMBER 1991 Volume 28 Number 11

IEEE
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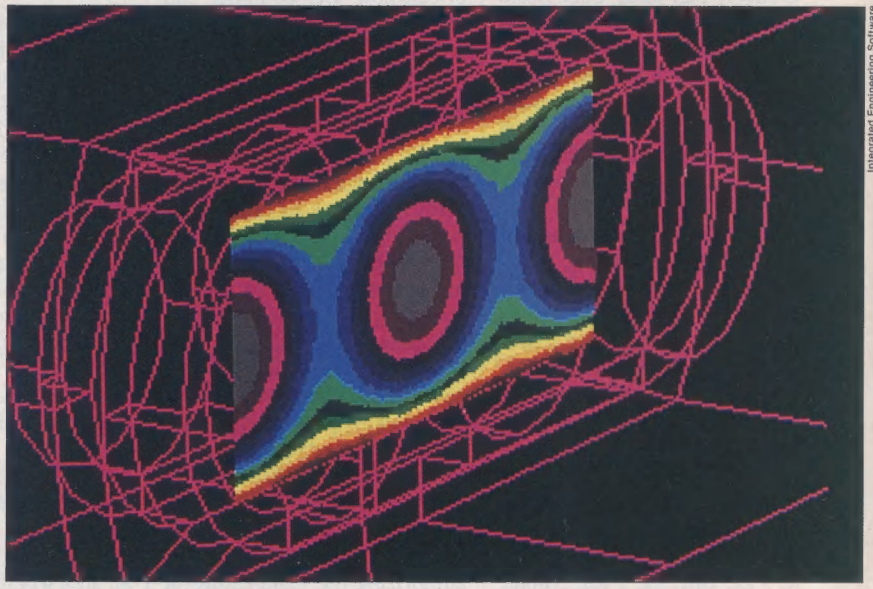
SOFTWARE

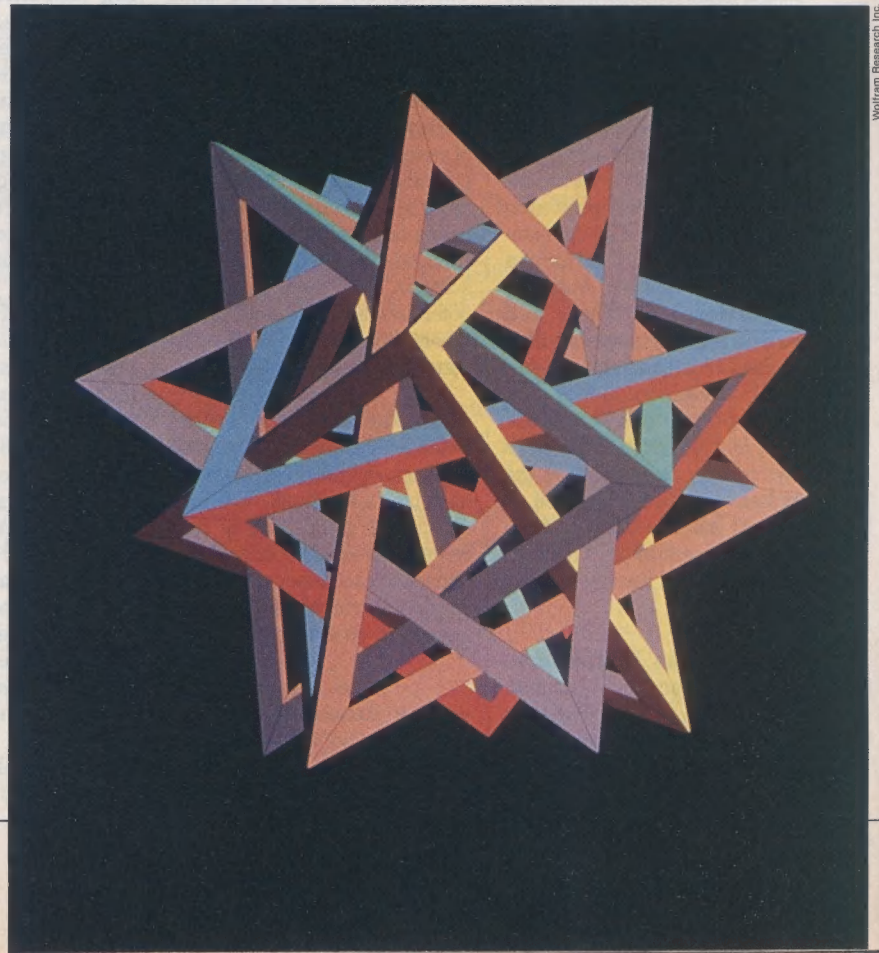
In this second annual report, *Spectrum* focuses on the updates made in engineering software for personal computers and workstations.



Integrated Engineering Software

The Coulomb software package provides three-dimensional simulations of the electric fields and stresses likely to occur within electrical and electronic equipment.

Basic building blocks of three-dimensional geometry are rendered here with the graphics primitives of the Mathematica software package. The image also shows off the program's lighting mode.



Wolfram Research Inc.

This ghostly screen reflection is provided by Keithley Asyst's Viewdac data acquisition package.

Cover: A display of the plasma breakdown of ionized rare gases within a globe is created by the PV-Wave Visual Data Analysis Software. See p. 44.
Photo: Precision Visuals Inc.

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Reflections

What's real anymore?

Not long ago I was visiting a large university as a member of some committee or other. Instinctively choosing my area of greatest incompetence, the university officials sent me over to the materials engineering department to inquire about whatever might be happening in that unknown territory. To begin my visit, I was introduced to a group of randomly chosen students. Of course they were all articulate, intelligent, enthusiastic, straight-A students with a great variety of extracurricular activities. That much I expected, based on past experiences with students randomly chosen by interested faculty members. What I did not expect, though, was that most of them would be women. Upon inquiry, I was told that almost half of the students in materials engineering were women.

"Why are there so many women over here, as compared with EE?" I asked. Before anyone could even answer, I blurted out an ill-considered defense of my inane question. "I mean, it's clean over there, . . . and there isn't all this heat and machinery . . ." I waved in the direction of the labs behind me. I think I was once again being defensive about the association of the word "engineer" with the hot, sweaty, soot-covered caricature of the railroad driver.

One female student looked at me with more than a hint of incredulity and disdain. "You can see and touch things here," she said. Glancing toward the nearby EE building, and barely suppressing a shiver, she added, "Nothing is real over there." Suddenly I had a vision of EE through her eyes. It was like seeing my cherished profession through Lewis Carroll's looking glass. *Nothing is real over there.* Could that be so?

My instinct was to protest, but there is a time and place for everything, and I changed the subject. She had hit a sensitive nerve; I had often pondered the reality of electrical engineering myself. Our field has always been divided into two camps—those who work with *things*, and those who don't. Some of us live in the real world of circuits and devices, while others inhabit the netherworld of mathematics and software. And the latter part is growing—reality is slipping away.

A friend who works in materials science used to start his talks with a simple chart displaying a single sentence. "Everything must be made of something," it said. In a few brief words it captured his pride in his field. What could be more fundamental than materials work? But one characteristic of engineers is that they like to argue. "Not so," I said to myself. Most of our stuff is made of nothing at all. It is made of software, of math, of conceptual thought. We live mostly in a virtual world.

When I was in high school, the sensual aspects of electrical equipment appealed to me. I can remember the smell of burning insulation, the feel of warm vacuum tubes, the sight of flickering orange filaments, and the sound of humming transformers. In contrast, I had a lot of trouble with the notion of imaginary numbers. What were they good for if they didn't exist? My teachers had a hard time explaining this to me. I don't think they knew themselves.

Tony Leonardi

In college the importance of that imaginary world grew, while the physical reality of electronics receded. Mathematical models stood in for the physical world. Even in the laboratory I viewed reality only through an oscilloscope as intermediary. Sometimes I wondered if physical behavior was really indicated by the squiggly line of glowing phosphor on the scope's face. I looked at the inert circuit on the lab bench with a touch of suspicion.

Now even the scopes are disappearing from labs. Who needs them? The computer monitor simulates a scope trace, showing the performance of a simulated circuit. Layers of software intercede and protect the sensitive human eye from actual observations. Engineers work on architecture, on increasingly abstract methods for formal specification, test generation, and validation. Nothing is human. Nothing smells. There is nothing to feel.

Today the physical circuits themselves are usually composed of anonymous chips like DSPs (digital signal processors). If someone should ask you what these chips do, you would be hard pressed to answer. "Well, it depends," you would say hesitantly, hoping to end the conversation. Unhappy with this evasion, the observer might look at the few lonely chips and complain that basically there was nothing inside the box. How can this thing work with nothing inside? But it is that seeming nothingness—the program—that makes the box do whatever it does.

I do not mean to lament the plunge through the looking glass into the world of unreality. I think that is the way technology is inevitably headed. There are too many constraints in the physical world, and functionality has become too complex to manipulate in terms of physical objects. But I confess to an occasional nostalgia for things that can be seen and felt.

A few years ago I hosted a dinner for winners of certain company awards for technical achievement. In an attempt to enliven the program I asked each winner's spouse to tell us what their mate did at work. Of course, I discovered once again that the typical spouse of an engineer has no clue about what their husband or wife does for a living. On this occasion there was but a single exception. The wife of one of the physicists claimed that she knew exactly what her husband did in the research lab. I wondered how she would explain his research in vapor phase epitaxy for growth of optoelectronic wafers. "He goes off every morning and spends the day slaving over a hot oven baking cookies," she said. Close enough, I thought—there is a down-to-earth explainability about the business of making things.

I have a number of friends now engaged in research into a field called "virtual reality." No one seems to take the title as I do—as an oxymoron. Surely this is the ultimate self-deception, the one that closes the loop. We have so perfected our virtual world that it will replace reality ever more closely. People will bake virtual cookies. We will smell the burning of virtual insulation, and hear the simulated hum of virtual transformers. We could easily explain this to Alice—it is all done with mirrors.

Robert W. Lucky

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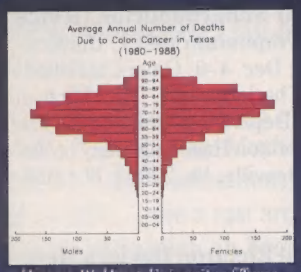

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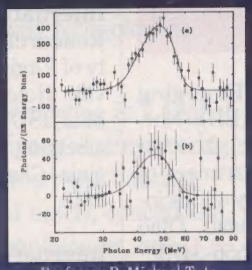

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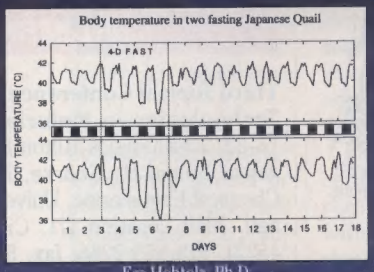

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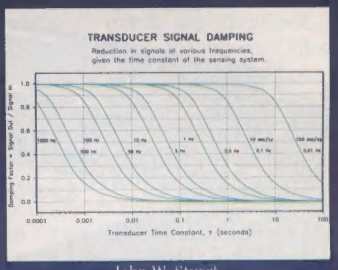

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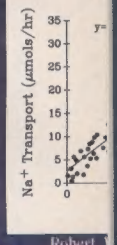

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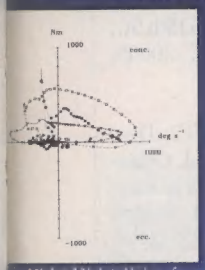

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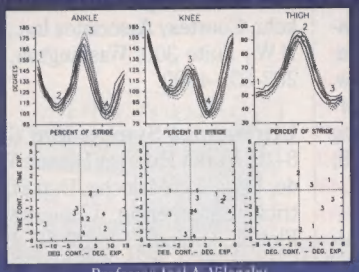

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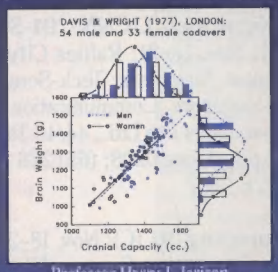

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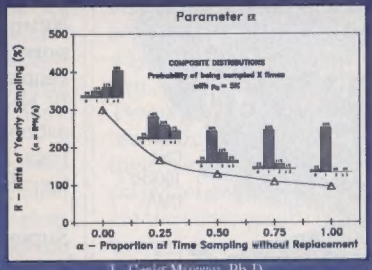

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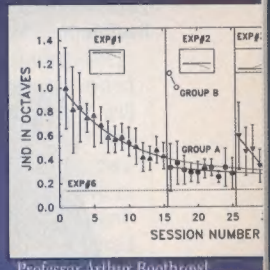
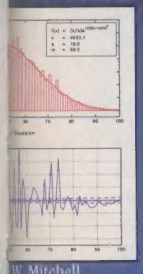


Professor Arthur Boothroyd, City University of New York[3]



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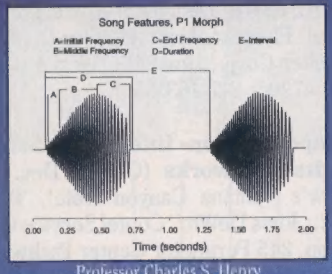

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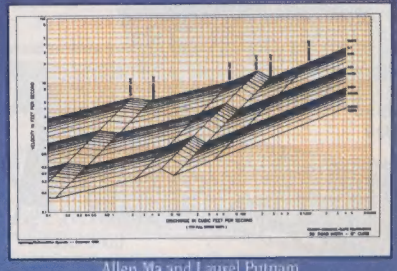
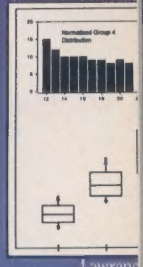


Allen Ma and Laurel Putnam, Los Angeles, CA



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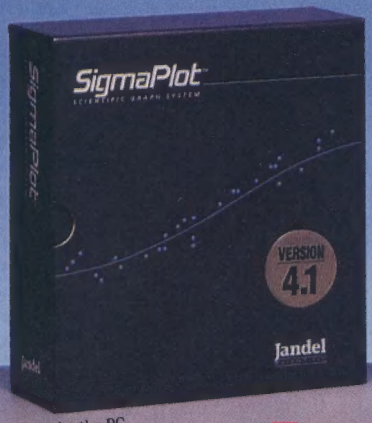

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Circle No. 6 for PC version. **Circle No. 7 for Mac version.**

Calendar

Meetings, Conferences and Conventions

NOVEMBER

Third Topical Conference on Emerging Technologies in Materials (ED); Nov. 17–22; Los Angeles Hilton Hotel, Los Angeles; Stevin H. Gehrke, Department of Chemical Engineering, University of Cincinnati, Mail Location 171, Cincinnati, Ohio 45221; 513-556-2766; fax, 513-556-3473.

International Joint Conference on Neural Networks–IJCNN '91-Singapore (NN); Nov. 18–21; Raffles City Convention Centre, Singapore; Teck-Seng Low, IJCNN '91-Singapore, Communication International Associates Pte Ltd., 44/46 Tanjong Pagar Rd., Singapore 0208; (65) 226 2838; fax, (65) 226 2877.

Supercomputing '91 (C); Nov. 18–22; Albuquerque Convention Center, Albuquerque, N.M.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

Wescon '91 (Region 6 et al.); Nov. 19–21; Moscone Convention Center, Brooks Hall/Civic Auditorium, San Francisco; Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, Calif. 90045; 213-215-3976 or 800-877-2668.

82nd Semi-Annual Seminar—Wireless Communications—An Overview of Issues and Technological Developments (COM); Nov. 21; United Engineering Center, 345 E. 47th St., New York, N.Y.; Bob Puttre, 914-683-3151, or Frank Stahl, 718-816-4468.

DECEMBER

Globe Telecommunications Conference (COM); Dec. 2–5; Civic Plaza, Phoenix, Ariz.; Elodia Chavez, US West Communications, 33 N. 3rd St., Room 901, Phoenix, Ariz. 85012; 602-235-1564; fax, 602-235-3534.

International Conference on Parallel and Distributed Information Systems (C); Dec. 4–6; Fontainebleu Hilton Resort, Miami Beach, Fla.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

International Semiconductor Device Research Symposium (MTT, University of Virginia); Dec. 4–6; Omni Charlottesville Hotel, Charlottesville, Va.; Michael Shur, ISDRS, Department of Electrical Engineering, Thornton Hall, University of Virginia, Charlottesville, Va. 22903; 804-924-8818.

International Electron Devices Meeting (ED); Dec. 8–11; Washington Hilton Hotel, Washington, D.C.; Melissa Widerkehr, Courtesy Associates Inc., 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-4990.

Ultrasonics Symposium (UFFC); Dec. 8–11; Hilton Hotel at Disney World, Orlando, Fla.; Don Malocha, Department of Electrical Engineering, University of Central Florida, Orlando, Fla. 32816; 407-823-2424.

Winter Simulation Conference–WSC '91 (C, SMC); Dec. 8–11; Arizona Biltmore Hotel, Phoenix, Ariz.; Jennifer E. Mishler, Pritsker Corp., Box 2413, West Lafayette, Ind. 47906; 317-463-5557.

Symposium on Integrated Services Digital Networks (COM); Dec. 8–12; Loew's Ventana Canyon Hotel, Tucson, Ariz.; Russ DeWitt, Contel Service Corporation, 245 Perimeter Center Parkway, Atlanta, Ga. 30346; 404-551-4911; fax, 404-391-1876.

Conference on Decision and Control (CS); Dec. 11–13; Brighton Metropole Hotel, Brighton, Sussex, England; P. Antsaklis, Department of Electrical and Computer Engineering, University of Notre Dame, Notre Dame, Ind. 46556; 219-239-5792; fax, 219-239-8007.

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And, if you believe that s, engineering, biology, one thing that separates sk from the thinking and experts or corporate obably like the balance

s who believe, as I do, es have insights to offer it a bright engineer or o at a cocktail party, will k frustrating. The prob- one of tone and empha- error.

issues are being dis- s rarely in doubt that he based on empirical evi- personal opinions. But are the subject, one is

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A few examples may help clarify my concerns. On p. 37, as part of an extended discussion of issues in risk perception, Lewis writes that "it is a curious paradox that aversion of future harm seems more important than the promise of future benefit." A few lines later he argues that one "important contributor to the perception of risk is the way risk is portrayed—the framing question." Any one who has read Kahneman and Tversky's papers on prospect theory will recognize these ideas. Yet Lewis cites neither them nor the sizeable body of empirical evidence that suggests these behaviors are the consequence of basic human cognitive processes—how our minds are wired up—not manifestations of lay ignorance.

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NOVEM

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International Join Neural Networks– pore (NN); Nov. 18–2 vention Centre, Singap IJCNN '91-Singapore, (national Associates Pte Pagar Rd., Singapore (fax, (65) 226 2877.

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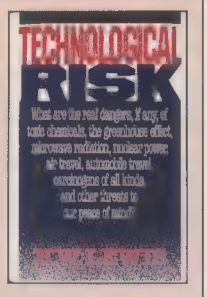
Books

Technological risk, social factors aside

M. Granger Morgan

Technological Risk. *Lewis, Harold W., W.W. Norton, New York, 1990, 353 pp., $22.95.*



Far too few first-class technical people have either the ability or the time to write clearly about technical subjects for general audiences. Thus, when someone like Harold W. Lewis, a physics professor at the University of California's Santa Barbara campus, writes a book on technological risk, I long to cheer the undertaking.

Indeed, much of the central portion of this book, which discusses the technical aspects of eight major classes of known or potential risks, is excellent. And, if you believe that knowledge of physics, engineering, biology, and statistics is the one thing that separates public ideas about risk from the thinking and beliefs of technical experts or corporate leaders, you will probably like the balance of this book as well.

However, readers who believe, as I do, that the social sciences have insights to offer that go beyond what a bright engineer or physicist can think up at a cocktail party, will find much of this book frustrating. The problem is subtle, more one of tone and emphasis than of outright error.

When technical issues are being discussed, the reader is rarely in doubt that he is reading statements based on empirical evidence, not Lewis' personal opinions. But when social issues are the subject, one is never sure.

The ideas of physicists like Richard Wilson, Richard Feynman, or Bernard Cohen, who have worked on risk issues, are clearly identified and attributed. Yet seminal contributions of social scientists like Daniel Kahneman, Amos Tversky, Baruch Fischhoff, Sarah Lichtenstein, Sam Peltzman, and Lester Lave as well as others in risk-related fields of social science (Bill Clark and Ralph Keeney come to mind) are discussed in anecdotal terms without attributions. Unless you have read the literature, you will often not understand where the empirical evidence ends and Lewis' personal views begin.

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Books

ting example in which preferences reverse when framings (portrayals of the conditions of the wager) are changed. The responses of a lay person and a mathematician or statistician are contrasted, with the implication that framing effects are due simply to ignorance. Further, it is implied that risk aversion is somehow *irrational*. The assumption is that "rational" means "willing to choose on the basis of expected value," even though risk aversion has been understood for years in economics and decision analysis as a rational response to risky choices by players with finite resources.

The work of Paul Slovic, Fischhoff, and Lichtenstein on lay perceptions of risk is attributed obliquely to an "Oregon-based research organization," but its main insight is not presented. In a nutshell, this insight was that lay people are fairly adept at ranking hazards in terms of expected numbers of deaths (on the order of magnitude, if not on the absolute values). Asked instead to rank hazards in terms of how risky they are, lay people produce quite different orderings. While Lewis describes this as reflecting a discrepancy between "fact and fancy," Slovic, Fischhoff, and Lichtenstein have demonstrated empirically that the difference is due to the lay view that "risk" involves multiple attributes. Expected deaths and injuries are not the only factor that counts. Issues such as equity, personal control, knowledge, immediacy or delay of consequences, and similar factors all enter into people's judgments about how "risky" something is.

There are important social and philosophical issues that Lewis handles very well. In the context of placing a value on future events, he several times raises the issue of whether there "is some outer limit for concern, some time beyond which there is just no point in fretting, whatever our sense of responsibility," and he argues reasonably that the answer is yes.

By far the best part of the book is the 185-page section titled simply "Specifics," which discusses in detail toxic chemicals; chemical carcinogenesis; highway safety; air transportation; ionizing radiation; nonionizing radiation; fossil fuels; and nuclear winter. While I encountered occasional problems related to the concerns mentioned above, and can find various technical nits to pick, I found this treatment for the most part very well done.

The book ends with a two-chapter "Coda" that begins with a tutorial on probability and statistics for nonspecialists. Most of this is well presented, appropriately emphasizing some simple rules of thumb for understanding the role of sample size in the uncertainty of an experiment's outcome.

The final chapter is a six-page epilogue that argues that in assessing and managing risks "the only way to deal with these genuinely deep issues is to understand them—we can't always count on luck." With that, I couldn't agree more!

M. Granger Morgan (F) is head of the department of engineering and public policy at Carnegie Mellon University in Pittsburgh, where he is also a professor in the department of electrical and computer engineering. His research deals principally with problems of technology and policy. He is a member of THE INSTITUTE*'s editorial board.*

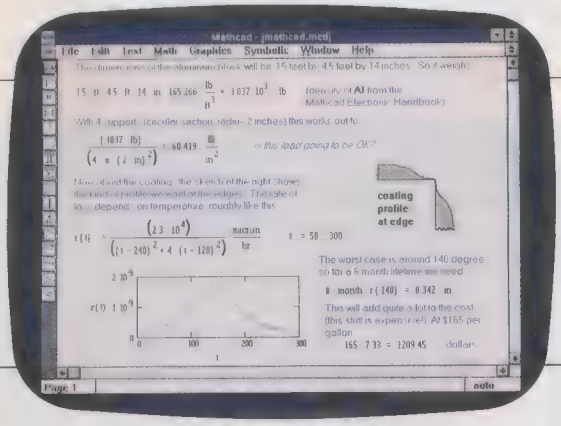
COORDINATOR: Glenn Zorpette

Recent books

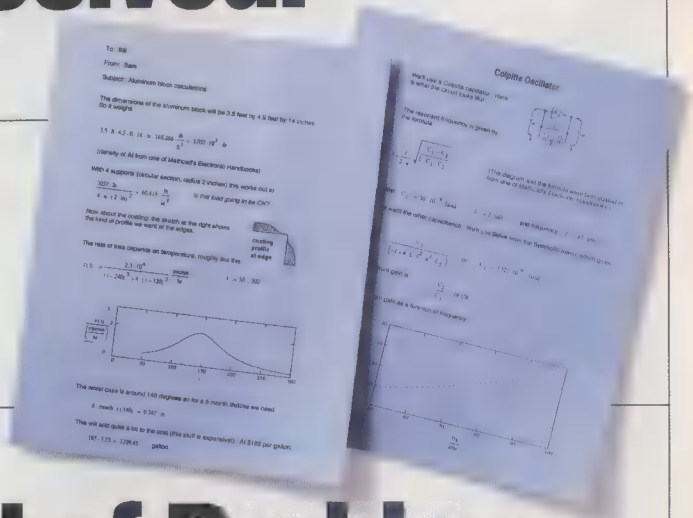
Electronic Techniques: shop practices and construction, 4th edition. *Villanucci, Robert S., et al.*, Prentice-Hall, Englewood Cliffs, N.J., 1991, 598 pp., $45.

Feedback Control Systems, 2nd edition. *Phillips, Charles L.*, and *Harbor, Royce D.*, Prentice-Hall, Englewood Cliffs, N.J., 1991, 664 pp., $56.

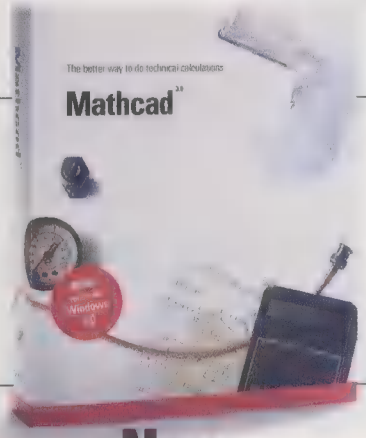
Calculations.



Solved.



Easy.



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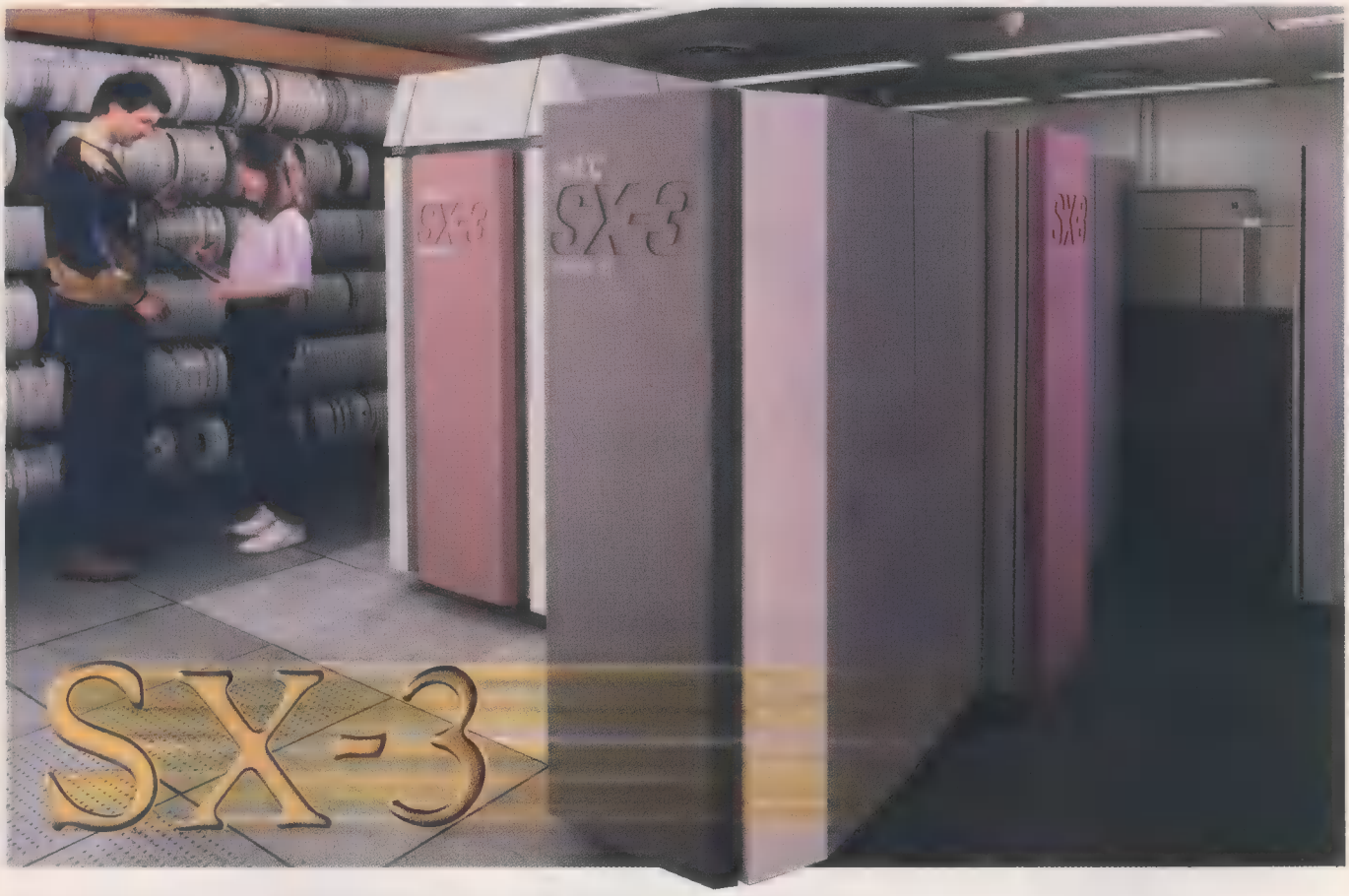

SUPERCOMPUTER STARTS UP AT THE UNIVERSITY OF COLOGNE.

An NEC supercomputer – SX-3 Model 11 – has just started service at the University of Cologne, Germany. The supercomputer system integrates resident LANs, mainframe computers, workstations and terminals. With 1.37GFLOPS speed, the SX-3 Model 11 is serving as a powerful core for inter-collegiate scientific computing services.

The SX-3 Series of supercomputers includes eight models ranging from a single-processor type with 0.68GFLOPS speed to the top-end, 4-processor 22 GFLOPS model. The world-class speed of SX-3 Series supercomputers comes from advanced system architecture, VLSIs with 70 picosec gate switching speed and high-density packaging.

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NUMBER 146

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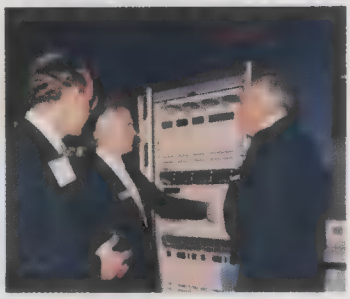

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Forum

Too broad a band

The article "Revising the script after Patriot" [September, pp. 49–52] gave the current operating frequency of the phased-array radar as being in the band 4–8 MHz, and stated that the band 8–12.5 GHz was being contemplated for an improved version of the system.

In fact, the current operating frequency of the system is within the much narrower band 5.250–5.925 GHz allocated by international agreement to radiolocation. Similarly, any operation in the band 8–12.5 GHz could only be in the narrower band, 8.5–10.5 GHz, also allocated to radiolocation by international agreement.

The United States is signatory to the treaty establishing these allocations, and adheres to them as a matter of policy to avoid interference to other radio communication services, many of which would suffer harmful interference from radar systems, and some of which are related to safety of life at sea and in the air. These allocations appear in the Table of Allocations of the ITU Radio Regulations, available to countries and individuals worldwide.

Richard G. Gould
Washington, D.C.

Controlling factors

The editorial "Aircraft traffic control" [March, p. 31] was a follow-on to the reporting of the collision between an arriving Boeing 737-300 and a Metroliner holding on the same runway at Los Angeles International Airport. My concern, as an aviation enthusiast, is over one's presumed ability to ascertain the causes of an accident from media reports, vague statistical relationships (operations versus staffing), and comment from a number of sources, none with expertise in accident investigation.

The article hints at severe staffing shortages and excessive overtime as contributing to the collision. This is simply not applicable to the Los Angeles Tower, which does not routinely schedule six-day work weeks or 10-hour days.

The airport surface detection equipment (ASDE) referred to in the article was originally intended to detect aircraft on an airport's movement surfaces in fog or similar visibility restriction. In virtually all U.S. air traffic control environments, the ASDE is used only under those conditions. The current operational versions are in fact old and difficult to maintain. In good visibility, albeit at night, it is conjecture to assume that the local controller would look away from the air traffic downward to the ASDE display, even if it were operating.

The author mentions a third factor: too many pilots communicating with a controller on one radio frequency causing frequency congestion. This is a point that the Federal Aviation Administration (FAA) and National Transportation Safety Board will surely address, as they would in any accident where communications were in use. However, controllers are trained to avoid accepting more traffic than they can effectively and safely control. The very reason air traffic controllers are required at any airport is to intervene or "control" unsafe and inefficient air traffic movement. I believe one of the commentators alluded to this in describing past air traffic control experiences.

I believe we need to examine all factors, not just human error, when assessing accident cause. It is an oversimplification to focus on perceived shortcomings of and to second-guess FAA management in the areas of staffing and technology choices. The air traffic system is very, very complex, costly, and difficult to manage. It is composed of numerous safety backups to offset system failings; others involving new or developing technology are always under consideration. It could be a mistake to shift the focus of new technology, resources, and available monies from the many ongoing safety-related endeavors to deal with what is currently in the news. To do otherwise would only further delay their implementation.

Gene P. Lawing
Washington, D.C.

Echoes of whistle-blowing

While I agree with the point made in A. David Rossin's letter [April, p. 6] that being paid for pointing out some of the problems in the lagging nuclear industry is not necessarily a measure of whistle-blower success, I disagree strongly with his selective memory of the important safety issues that we addressed in our testimony to Congress and to the various NRC [Nuclear Regulatory Commission] committees and individuals following our resignations. In that testimony, we identified more than 20 design defects undermining the then-proclaimed safety of nuclear generating stations. Rossin may wish to believe that none of these safety issues had any effect on his (Chicago-based Commonwealth Edison Co.) plants, but that simply is not true.

As one example (of many) of the design-error corrections that were subsequently implemented at the Commonwealth BWRs [boiling water reactors], it was reported, *by Commonwealth*, to the Illinois Commerce Commission in 1982 that they were spending in excess of US $70 million ($38 million already spent in 1982 and another $32 million estimated to go) to correct the underdesigned containment torus supports at four of the six Commonwealth BWRs. This was but one part of the massive effort to correct the continuing hydrodynamic load design problems that were thoroughly discussed in our testimony before Congress. That problem alone has conservatively cost U.S. electric utilities and (naturally) ratepayers billions of dollars over the last 15 years. The past 15 years' experience has shown me that management attention resulting from public pressure can make things happen at a much faster pace.

Our clients include, in addition to Rossin's antinuclear groups and political opportunists, the United States' NRC, Department of Energy, General Accounting Office, and Office of Technology Assessment, as well as the Swedish Statens Karnkraftinspektion (NRC equivalent), the former Democratic and Republican governors of California, the Washington Public Power Supply System, the Nebraska Public Power District, and government agencies in Germany, Spain, Italy, and Norway.

All potential whistle-blowers should understand that the "selective memory" phenomenon described above is a common attribute among the industrial/governmental leaders of large businesses such as nuclear power companies. If you are going to do it, expect a lot of flak, and make sure of your ground.

Dale G. Bridenbaugh
San Jose, Calif.

Proceedings available

For a complete set of the Institute of Radio Engineers' *Proceedings* from 1925 to 1971, contact J. K. Johnson, Box 352, RR 1, Waitsfield, Vt. 05673; 802-496-2510. —*Ed.*

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Technically speaking

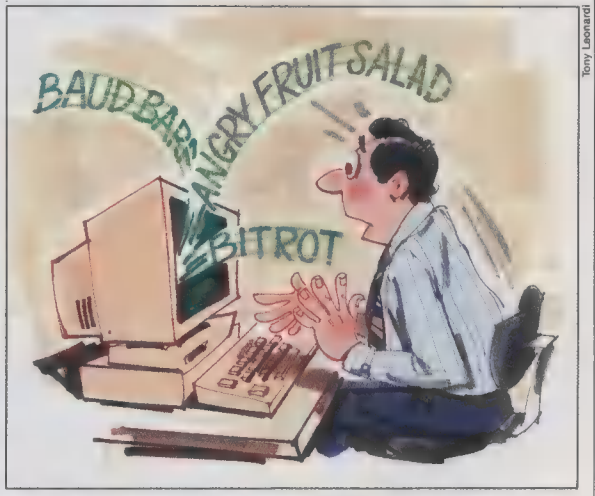
Ever work in 'troglodyte mode'?

Few subcultures are as shrouded in mystery or folklore as is the hacker's and software programmer's. Even engineers are in the dark about much of what goes on after they hit RETURN, while to lay people, the jargon that hedges in the world of the PUSH, POP, and PRINTF can seem impenetrable.

By now the public image of those who deal with software is much fantasy fact, so it is to be hoped that the arrival of *The New Hacker's Dictionary* (MIT Press, Cambridge, Mass., US $10.95) will clear the air. The book collates over 16 years of work by an informal group of computer users, who have taken inputs from computer professionals and students all over the world and compiled them in a master "jargon file" on the Internet research network.

"We wanted it to entertain people, but also be a serious work for lexicographers and scholars studying the hacker culture," one of the dictionary's editors, Eric Raymond, told *IEEE Spectrum*. "The culture I live in is being threatened by an oversimplified image of hackers as criminals or vandals. I want to reclaim the word, and I want the public to see the positive side of hacking."

Some of the more colorful terms from *The New Hacker's Dictionary* are excerpted here (with some minor editing). Even as the book is being published, the original file (in flat ASCII form) is available for downloading over Internet ftp from mc.lcs.mit.edu in file pub/jargon/jargon296.ascii.



Tony Leonardi

angry fruit salad: *n.* A bad interface design that uses too many colors.
baud barf: /bawd barf/ *n.* The garbage one sometimes gets on the monitor when encountering spurious data, caused by an incorrect protocol setting, by line noise disrupting the connection, or by picking up a voice extension on the same line.
beige toaster: *n.* A Macintosh PC.
bit rot: *n.* The hypothetical disease of unused programs or features that stop working after enough time has passed, even if "nothing has changed." The theory explains that bits decay as if radioactive.
bletcherous: /blech-(e)-rus/ *adj.* Disgusting in design or function; esthetically unappealing.
branch to Fishkill: [from the location of one of IBM Corp.'s facilities] *n.* Any unexpected jump in a program that produces catastrophic or just plain weird results.
bulletproof: *adj.* Descriptive of an algorithm or implementation considered extremely robust and capable of correctly recovering from any imaginable exception condition. This is a rare and valued quality.
chrome: *n.* Showy features contributing little or nothing to the power of system.
crufty: /kruhf'tee/ *adj.* Poorly built, possibly overly complex.
demigod: *n.* Hacker with a national reputation and major role in the development of design, tool, or game known to over half of the hacker community.
examining the entrails: *n.* Rooting through core dump or hex image to discover the bug that downed your program or system.
face time: *n.* Time spent interacting with somebody face-to-face (as opposed to over an electronic link). Thus, "Oh, yeah, I spent some face time with him at the last Usenix."
glork: /glork/ *interj.* Term of mild surprise, tinged with outrage, uttered when, say, trying to save the results of two hours of editing, only to find the system has crashed.
guru: *n.* An expert, implying not only the possession of wizardly skill but history of being knowledge resource for others.
hamster: *n.* A particularly slick little piece of code that does one thing well; a small, self-contained hack. The image is of a hamster happily spinning its exercise wheel.
hobbit: *n.* The High Order Bit of a byte.
LER: /el-ee-ar/ *n.* A light-emitting resistor (that is, one in the process of burning up).
lots of MIPS but no I/O: *n.* Attributes of a technically brilliant person unable to communicate with others effectively. Technically, the phrase describes a powerful machine bottlenecked on I/O.

(Continued on p. 88)

PC MAGAZINE
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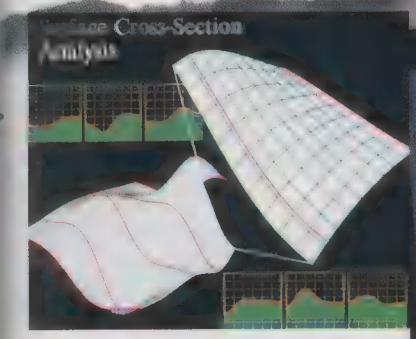

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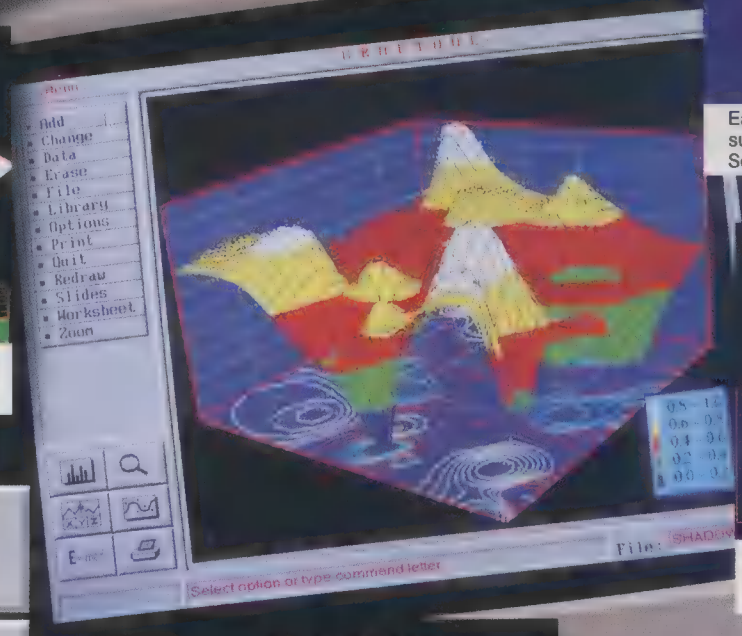

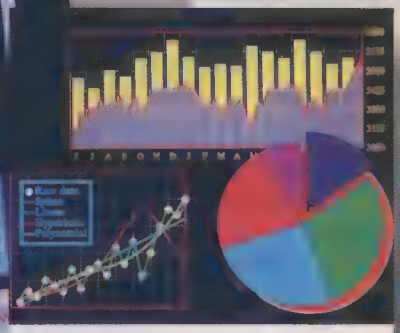

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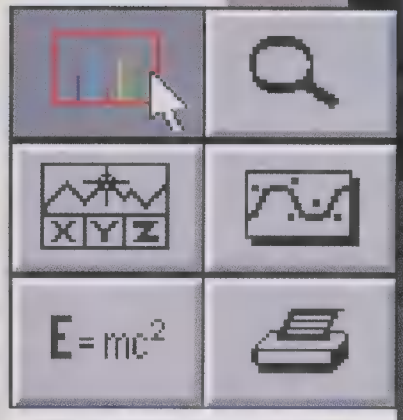

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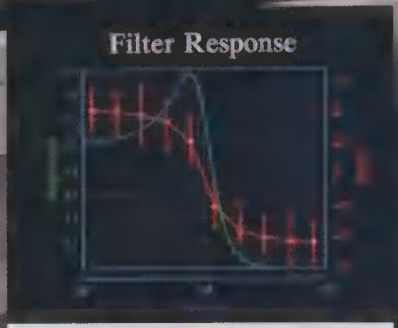

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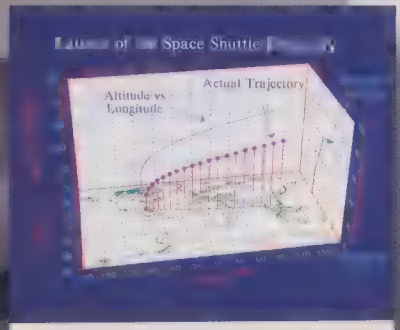

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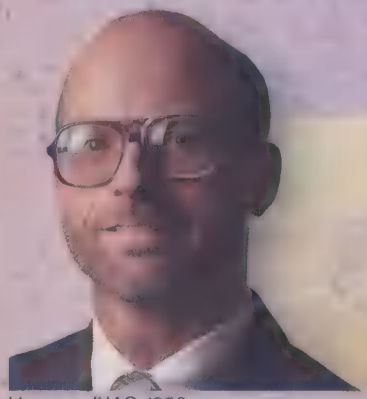

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Hopi Pattern Mathematics, 6th century

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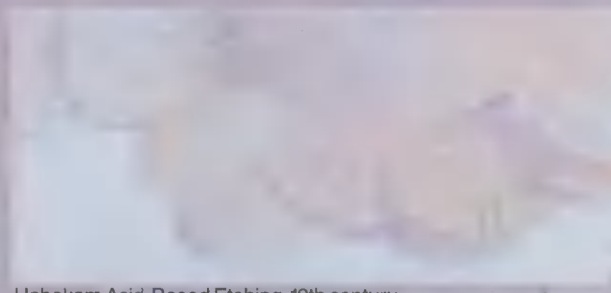
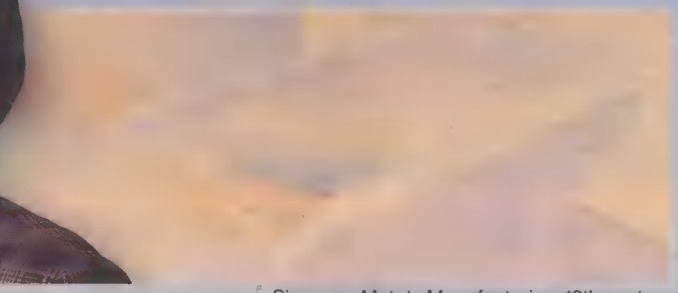


Hohokam Acid-Based Etching, 10th century

Motorola GEG, 1989

Intel, 1991



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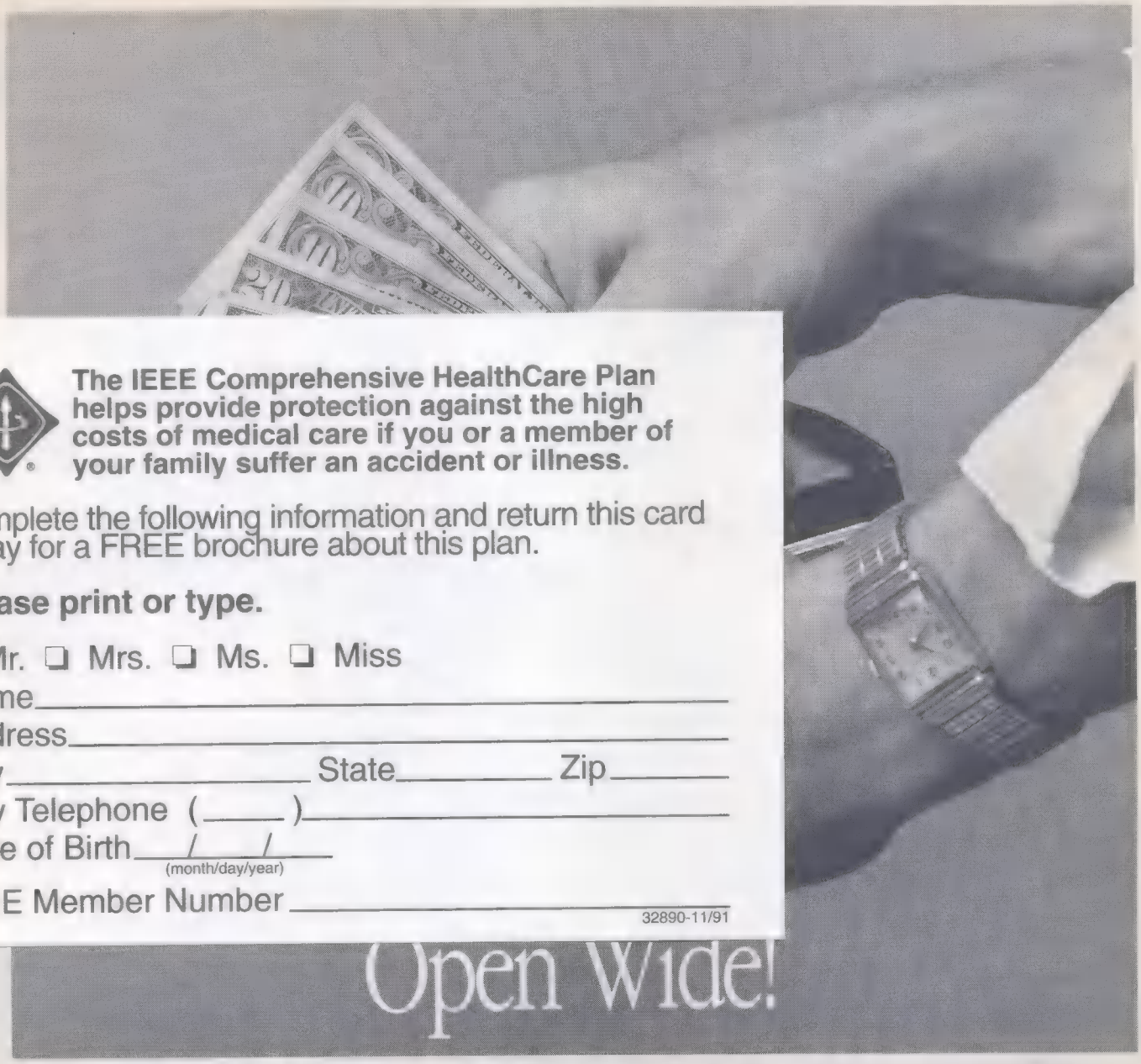

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Calendar

(Continued from p. 8)

22nd Annual Semiconductor Interfaces Specialist Conference (ED); Dec. 11–14; Disney Village Resort, Orlando, Fla.; Steve Lyon, Department of Electrical Engineering, Princeton University, Princeton, N.J. 08544; 609-258-4635.

Power Semiconductor Devices Workshop (ED); Dec. 12–13; National Institute of Standards and Technology (NIST), Gaithersburg, Md.; David Blackburn, NIST, Building 225, Room B310, Gaithersburg, Md. 20899; 301-975-2053.

International Conference on Emerging Optoelectronic Technologies (ED); Dec. 16–20; Indian Institute of Science, Bangalore, India; Krishna Shenai, KW-A1715, General Electric CRD, River Road, Schenectady, N.Y. 12301; 518-387-5911; fax, 518-387-5058.

JANUARY 1992

International Conference on Wafer Scale Integration (C, CHMT); Jan. 22–24; Fairmont Hotel, San Francisco; Peter W. Wyatt, MIT Lincoln Laboratory, Box 73, Lexington, Mass. 02173-0073; 617-981-7232 or 617-862-9057.

Power Engineering Society Winter Meeting (PE); Jan. 26–30; New York Hilton at Rockefeller Center, New York City; J.G. Derse, 704 Timberbrooke Dr., Bedminster, N.J. 07921; 908-658-4042.

Eighth Optical Fiber Sensors Conference–OFS 8 (LEO); Jan. 27–31; Monterey Sheraton Hotel, Monterey, Calif.; Glenda McBride, IEEE/LEOS; 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3896.

Annual Reliability and Maintainability Symposium (R); Jan. 28–30; Riviera Hotel, Las Vegas, Nev.; V.R. Monshaw, RCA Corp., Astro-Electronics, Box 800 MS 55, Princeton, N.J. 08540; 609-426-2182.

FEBRUARY

International Workshop on Research Issues on Data Engineering (C); Feb. 2–3; Sheraton Hotel, Tempe, Mission Palms, Ariz.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

Conference on Optical Fiber Communication–OFC '92 (COM, LEO); Feb. 3–7; San Jose Convention Center, San Jose, Calif.; Susan Evans, IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3896.

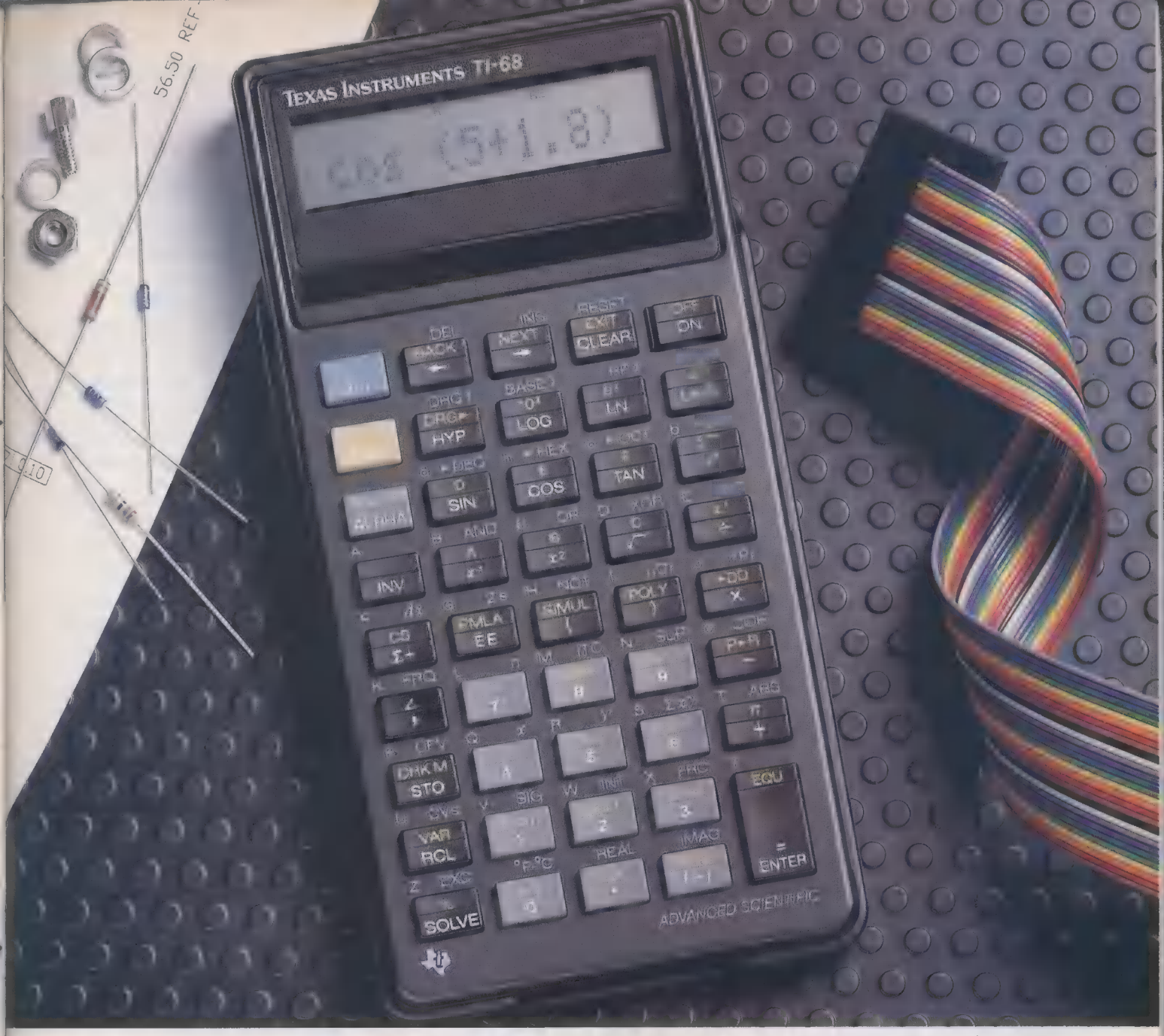
International Solid State Circuits Conference–ISSCC (Solid State Circuits Council et al.); Feb. 19–21; San Francisco Hilton Hotel, San Francisco; Diane Suiters, Courtesy Associates Inc., 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-347-5900.

Applied Power Electronics Conference and Exposition (PEL); Feb. 23–27; Westin Hotel, Boston; Melissa Widerkehr, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-4990; fax, 202-347-6109.

MARCH

First International Fuzzy Systems Conference (COM, IE, NN); March 8–12; Town and Country Hotel, San Diego, Calif.; Nomi Feldman, Meeting Management, 5665 Oberlin Dr., Suite 110, San Diego, Calif. 92121; 619-453-6222.

(Continued on p. 18M)



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TEXAS INSTRUMENTS

What You Can Do for National Engineers Week

How can individual IEEE members contribute to National Engineers Week (NEW)? You can participate in at least one of many possible activities.

Some NEW activities are directed toward precollege students and include advising students on Career Days, leading field trips for students and teachers to local industries, conducting seminars for teachers on technology and engineering topics, and presenting awards to outstanding science and math students and to teachers for excellence in science and math instruction. The NEW Discover "E" program encourages engineers to give talks at their local schools about the role of science and engineering in the modern world.

A second group of activities focuses on public officials and business leaders and includes such projects as organizing meetings with local legislators and industry leaders to discuss topics of concern to the engineering community. A third group of activities centers on publicizing NEW through newspaper articles or supplements.

This year's National Engineers Week theme is "Engineers Turning Ideas Into Reality." IEEE-USA's NEW Committee is depending on local Section and Chapter members to join in the annual celebration of an event dedicated to the engineering profession. NEW Planning Kits are being sent to all IEEE Sections, Societies, and Student Branches. For more information about NEW 1992, contact the IEEE-USA Office in Washington, D.C. ✦

PACE Workshop Features Employment and Education

Employment and education issues dominated the presentations and discussions at the 16th Annual Professional Activities Committees for Engineers (PACE) Workshop held over Labor Day weekend, August 30 to September 2, in Philadelphia, Pennsylvania. More than 200 Workshop participants looked at long-term employment trends, especially in terms of the current recession and decrease in defense expenditures, and the related issues of increasing U.S. competitiveness and improving precollege math and science education.

IEEE-USA's Employment Assistance Committee described several actions taken to ease the threat or reality of unemployment for IEEE's U.S. members. IEEE employment assistance seminars and job fairs, conducted by The Lendman Group, have been held in 14 cities since the fall of 1990.

A complete report on the Workshop will be available shortly from the IEEE-USA Office in Washington, D.C. ✦

Job Fairs Update

IEEE Job Fairs and Job Search Seminars will be held at these locations during November and December 1991.

DATE	LOCATION	EVENT
November 2	Boston Section	Job Search Seminar
November 2	Nat'l. Capital Area Council	Job Search Seminar
November 4-5	New York Section	Job Fair
November 4-5	Nat'l. Capital Area Council	Job Fair
November 5	Boston Section	Job Fair
November 6	Boston Section	Job Fair
November 16	Bay Area Council	Job Search Seminar
November 18-19	Bay Area Council	Job Fair
December 9-10	North Jersey Section	Job Fair
December 9-10	Chicago Section	Job Fair
December 9-10	Houston Section	Job Fair

Job Fairs are open to all engineers. To locate the Fair nearest you, contact the IEEE Career Fairs Coordinator at (800) 562-2820; in Virginia, call (800) 533-1827. ✦

Updated Supercomputing Glossary Published

IEEE United States Activities recently published the 2nd edition of ***Supercomputing: An Informal Glossary of Terms,*** a work developed by a subcommittee of IEEE-USA's Committee on Communications and Information Policy. Specifically limited to supercomputing, this brief lexicon is intended to help both novices and experts communicate better.

The 24-page, new edition of the Glossary may be purchased through the IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, New Jersey 08855-1331; telephone (800) 678-IEEE or (908) 981-1393. Ask for IEEE Catalog No. UH0182-6; prices are $7.50 for members and $9.95 for nonmembers. ✦

IEEE-USA Supports Federal Efforts to Create a National Energy Policy

IEEE's United States Activities Board Chairman Michael J. Whitelaw recently wrote to Members of the U.S. Senate to express support for advanced nuclear technology development and for the nuclear licensing reform provisions of S. 1220, the ***National Energy Security Act of 1991.*** The letter stated that "IEEE United States Activities believes nuclear power can and must play a critical role in assuring an adequate supply of reliable, low-cost, and environmentally acceptable electricity for the future."

IEEE-USA and its Energy Policy Committee (EPC) have made a number of efforts to assist Congress and the Executive Office during their deliberations on the National Energy Strategy. EPC has also testified in support of energy efficiency, photovoltaics and renewable energy, fusion, and energy storage systems technology.

Previously in *Professional Perspective*, Charles N. Claar, EPC Chairman, and IEEE-USA Administrator of Professional Programs Chris J. Brantley began a two-part report describing efforts by the Bush Administration to advance a National Energy Strategy (NES) and outlining IEEE-USA's positions on related energy issues. To obtain the complete report, copies of positions, or information on current energy legislation, contact the IEEE-USA Office in Washington, D.C. ✦

From the Editor...

Welcome to *Professional Perspective* in its temporary new home. IEEE's United States Activities Board has paid for this advertising space in *Spectrum*, in order to keep bringing news of professional activities to U.S. members. We'll appear in *Spectrum* again in 1991, returning in 1992 as an IEEE United States Activities insert in *The Institute*.

For now, space limitations prevent publication of full-length articles. Instead, we are presenting brief summaries, but you may request copies of reports and information on many professional programs for U.S. members from IEEE-USA's Washington, D.C. Office. Please don't hesitate to call (202) 785-0017; fax (202) 785-0835; or write to 1828 L Street, N.W., Washington, D.C. 20036-5104.

We are especially pleased to report the work of the Pensions Committee, the Energy Committee, and PACE (Professional Activities Committees for Engineers). Look for our first 1992 issue, which will feature IEEE-USA's 1991 Annual Report, in *The Institute*.

Any comments? Questions? Complaints? Suggestions? Write to me in care of the IEEE-USA Office in Washington, D.C.

—Dan Rosich
Editor in Chief

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IEEE-USA Promotes Legislation to Improve Pension Portability: Congressional Action Depends on You

IEEE-USA's Pensions Committee is coordinating a major effort to promote the enactment of Federal legislation to expand pension coverage, improve the portability of pension benefits when workers change jobs, and increase individual savings for retirement.

This effort is an outgrowth of IEEE-USA's longstanding concerns about the nation's voluntary private pension system. Its deficiencies reduce its effectiveness as a reliable source of retirement income for millions of American workers. Less than half of these workers are covered by employer-sponsored pension plans. Moreover, substantial numbers of covered workers—including many engineers and scientists—incur substantial losses in benefits, if they change jobs prior to retirement.

IEEE-USA Recommends These Measures

IEEE-USA supports legislation to expand pension coverage and increase savings for retirement by requiring employers that do not offer pension plans to set up voluntary salary-reduction savings arrangements for their employees.

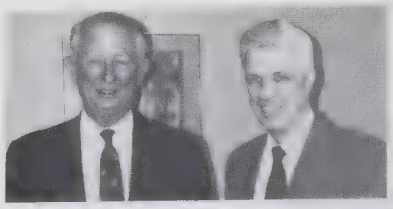
IEEE-USA also recommends that Congress help to preserve the value of earned pension benefits when workers change jobs by:

- reducing vesting requirements for full time employees;
- permitting vested employees to transfer earned benefits to Individual Retirement Accounts when they change jobs; and
- increasing penalty taxes on consumption of pre-retirement lump-sum distributions from pensions and other retirement savings plans.

Pension Coverage and Portability Improvement Act Introduced

Earlier this year, Congressman Sam Gibbons (D-Florida), the second ranking Democrat on the House Ways and Means Committee, introduced H.R. 2390, the ***Pension Coverage and Portability Improvement Act.*** This legislation is based on IEEE-USA's retirement income policy recommendations.

IEEE-USA is currently mobilizing support for this important legislation in the House of Representatives and the Senate, among major national engineering, scientific and technical organi-



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zations, and among employers of engineers and scientists.

One key element of IEEE-USA's lobbying efforts is the presentation of testimony before key Congressional committees. So far this year, Pensions Committee members have testified before the House Select Committee on Aging, the House Ways and Means Committee, and the Senate Finance Committee.

Congressional Outlook

IEEE-USA's legislative initiative comes at a time of growing public concern about declining personal savings and the need to ensure an adequate income in retirement for increasingly mobile workers. These concerns are reflected in several legislative proposals designed to improve access to pension coverage.

How You Can Help

IEEE-USA is pleased to report that all major pension expansion and simplification proposals include provisions designed to expand pension coverage. The Gibbons bill, however, is the only bill that would help to preserve the value of earned pension benefits when workers change jobs. It is the only bill that promotes improved portability.

The most effective way to make this point to the U.S. Senators and Representatives who will be voting on this critically important legislation is to tell them so. You can help by taking a few minutes to urge your own Senators and Representatives to support the ***Pension Coverage and Portability Improvement Act*** (H.R. 2390) when Congress takes up pension reform legislation later this year or early next year. (See box.)

More Information Available

IEEE-USA's Pensions Committee is responsible for tracking developments in the public and private sectors, making policy recommendations to IEEE's United States Activities Board, and educating IEEE's U.S. members on pensions and other retirement income issues. If you would like additional information, contact the Pensions Committee, in care of the IEEE-USA Office in Washington, D.C. ✦

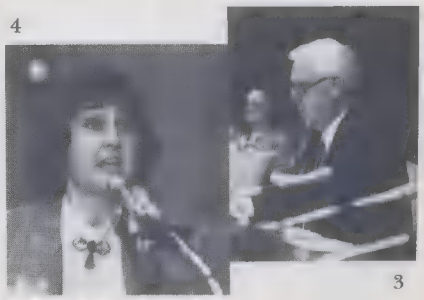
Suggested Letter of Support

"Dear Representative (or Senator): I am writing to you as a constituent and engineer to urge you to support H.R. 2390, the ***Pension Coverage and Portability Improvement Act,*** as introduced by Congressman Sam Gibbons (D-Florida).

"Prompt enactment of these provisions is needed to strengthen the nation's voluntary private pension system and ensure a financially secure retirement for America's increasingly mobile work force.

"Thank you for your support."

Sign your letters, and mail them to the U.S. House of Representatives, Washington, D.C. 20515, and the U.S. Senate, Washington, D.C. 20510. ✦



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1. **Congressman Sam Gibbons (l.) and IEEE-USA Pensions Committee Chairman George F. McClure.**

2. **IEEE-USA lobbyist James C. Corman (l.), former IEEE President John J. Guarrera (c.), and Congressman Charles B. Rangel (D-NY).**

3. **Congressman Rod Chandler (R-WA) queries witnesses at Ways and Means Subcommittee hearings on pension legislation**

4. **IEEE-USA Pensions Committee member Mona K. Draper testifies in support of pension legislation at Senate Finance Committee hearings in Washington.**

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Calendar

(Continued from p. 18H)

Southcon '92 (Region 3); March 10–12; Orange Country Convention/Civic Center, Orlando, Fla.; Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, Calif. 90045; 213-215-3976 or 800-877-2668.

Fourth International Conference on Microelectronic Test Structures (ED); March 17–19; Catamaran Resort Hotel, San Diego, Calif.; Michael W. Cresswell, National Institute of Standards and Technology, Building 225, Room B360, Gaithersburg, Md. 20899; 301-975-2072; fax, 301-975-2128.

Multichip Module Conference (ED); March 17–March 20; Cocoanut Grove, Santa Cruz, Calif.; Simon Wong, Electrical Engineering Department, CIS 202, Stanford University, Stanford, California 94305; 415-725-3706.

International Reliability Physics Symposium (ED); March 30–April 2; Town and Country Hotel, San Diego, Calif.; Harry Schafft, National Institute of Standards and Technology, Building 225, Room B360, Gaithersburg, Md. 20899; 301-975-2234; fax, 301-948-4081.

APRIL

Network Operations and Management Symposium (COM); April 6–9; Peabody Hotel, Memphis, Tenn.; Jill Pancio, Pacific Bell, Unit of Pacific Telesis Group, 7620 Convoy Court, San Diego, Calif. 92111; 619-268-6135; fax, 619-292-1509.

Southeastcon '92 (Region 3 et al.); April 12–15; Wynfrey Hotel, Birmingham, Ala.; Wayne Owen, South Central Bell, 600 N. 19th St., Birmingham, Ala. 35203; 205-321-2299.

Intermag '92 (MAG); April 13–16; Adams Mark Hotel, St. Louis, Mo.; Courtesy Associates Inc., 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-5088.

Fourth International Conference on Indium Phosphide and Related Materials (ED); April 21–24; Newport Sheraton, Newport, R.I.; Susan Evans, IEEE/LEOS Executive Office, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3896; fax, 908-562-1571.

Seventh Conference on Semi-Insulating III-V Materials (ED); April 21–24; Krystal Hotel, Ixtapa, Mexico; William Ford, Harris Corp., Harris Microwave Semiconductor, 1530 McCarthy Blvd., Milpitas, Calif. 95035; 408-433-2222; fax, 408-432-3268.

Recent books

(Continued from p. 12)

Norton Utilities 5.0: an illustrated tutorial. *Evans, Richard,* Windcrest Books, Blue Ridge Summit, Pa., 1991, 343 pp., $26.95.

Trends in Theoretical Physics, Vol. 2. Eds. *Ellis, Paul J.,* and *Tang, Y.C.,* Addison-Wesley, Redwood City, Calif., 1991, 416 pp., $48.50.

Research and Development in Expert Systems: VII. Eds. *Addis, T.R.,* and *Muir, R.M.,* Cambridge University Press, New York, 1990, 317 pp., $44.50.

Application Environment Specification (AES), revision B. *Open Software Foundation,* Prentice-Hall, Englewood Cliffs, N.J., 1991, 1083 pp., $39.

(Continued on p. 74H)

For High Temperature Superconductor Answers, Go to the Source.

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"STI is now working with the microwave industry in an aggressive program to develop superior passive components with HTS. This includes resonators, filters, oscillators, delay lines and subsystems. In addition to HTS films, we provide custom HTS circuits, components and assemblies. And our HTS circuit fabrication department builds customers' designs from mask making to packaging.

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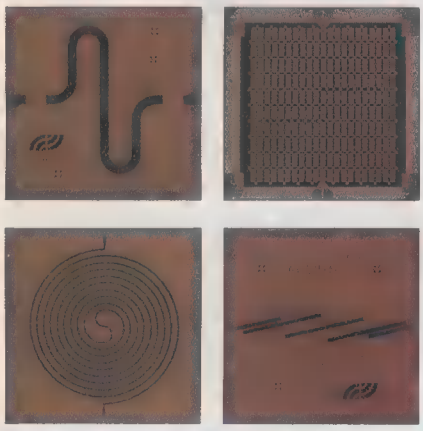
Jim Bybokas
Vice President
Superconductor Technologies



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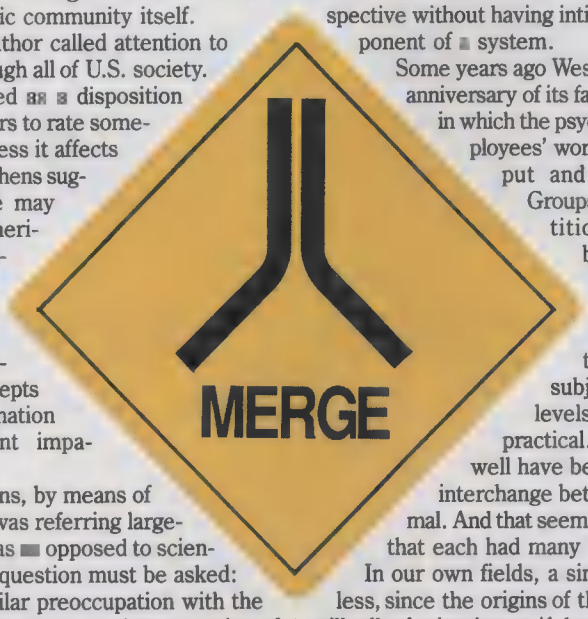
Circle No. 29

NOVEMBER 1991 Volume 28 Number 11

Closing the gap

When the *Columbia Journalism Review* recently ran an article on the topic of deconstruction, the theme was less the topic itself than why journalists have overlooked the 25-year-old academic issue. (Deconstruction, incidentally, is a complex concept having to do with the idea that classic distinctions between once-definitive terms are changing or becoming invalid. But not to worry, deconstruction is not the subject of this column.) The author, Mitchell Stephens, a professor of journalism at New York University, attributed the dearth of coverage of the concept to a general condescension of the press toward those who study philosophy and abstract ideas. The reason could not be dullness of the topic, Stephens concluded, because it has engendered emotion and dissension among the academic community itself.

Extending his thesis, the author called attention to a similar thread that runs through all of U.S. society. It is perhaps best characterized as a disposition among most movers and shakers to rate something of little consequence unless it affects the gross national product. Stephens suggests the patronizing attitude may have its roots in the grand American tradition of mocking intellectual pretensions, especially when those pretensions are expressed in large, unfamiliar words. Also, journalists who refuse to deal with ideas and concepts may be laboring under information overload and get-to-the-point impatience, he says.



I must point out that Stephens, by means of his example, deconstruction, was referring largely to abstract philosophical ideas as opposed to scientific theory. Nevertheless, the question must be asked: do we engineers permit a similar preoccupation with the practical to limit our vision? Do we succumb to a version of the journalists' tunnel vision too often when we discount the qualifications of university professors in contributing to "real world" solutions?

There is a certain macho attitude that those of us who consider ourselves "industry types" sometimes assume—implying that a teacher cannot be expected to be sensitive to the practitioner's challenges without considerable hands-on experience in designing, developing, or manufacturing products for a profit-making organization.

Such a belief is a gross misapprehension. As former IEEE President Jerome J. Suran put it, "The world is very large compared to one's own background and past experience may have little relevance to the world of tomorrow." He added, "If experience is truly to add value to a lesson, one must extract the universals and not the specifics." Suran should know whereof he speaks; now teaching at the University of California, Davis, he was a career engineer-executive at General Electric Co.

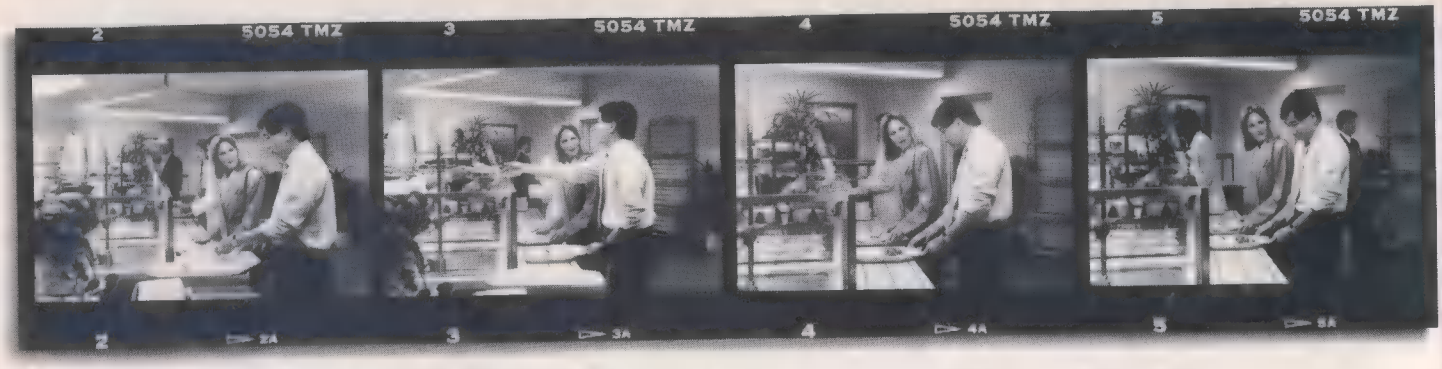
We've all seen people who try to solve problems with techniques they used successfully 10 years ago, techniques that often do not work again in a new setting. This is hardly to say that practical experience is not helpful to a teacher, but rather that academics can offer insight and a systems perspective without having intimate knowledge of every component of a system.

Some years ago Western Electric Co. celebrated an anniversary of its famous Hawthorne experiments, in which the psychological effects of altering employees' working environments on their output and efficiency were measured. Groups of industrial engineering practitioners and academics were brought together to discuss the Hawthorne experiments and their implications. An observer noted that the two groups, though addressing the same subject, were discoursing on two levels, one theoretical and the other practical. The convocation might just as well have been held in different cities; the interchange between the two levels was minimal. And that seemed a shame, because it appeared that each had many insights to offer the other.

In our own fields, a similar gap has existed, more or less, since the origins of the profession. Some engineers still talk of scientists as if they were queer ducks, too far removed from making practical contributions to deserve much attention, and of academics as semi-obsolete and too engrossed in theory.

U.S. engineers might benefit by taking a cue from cultures where philosophical and theoretical thinking is taken more seriously. It could foster beneficial communication among engineers, scientists, and academics.

Donald Christiansen



"So you're testing a prototype already?" *"Yep. Mmm, lasagne."* "Patents checked?"

"Wouldn't test otherwise." "Meet industry standards?" *"It'll comply..."*

...which I don't think is true of the meatloaf." "Say, where're you getting so much help, anyway?"

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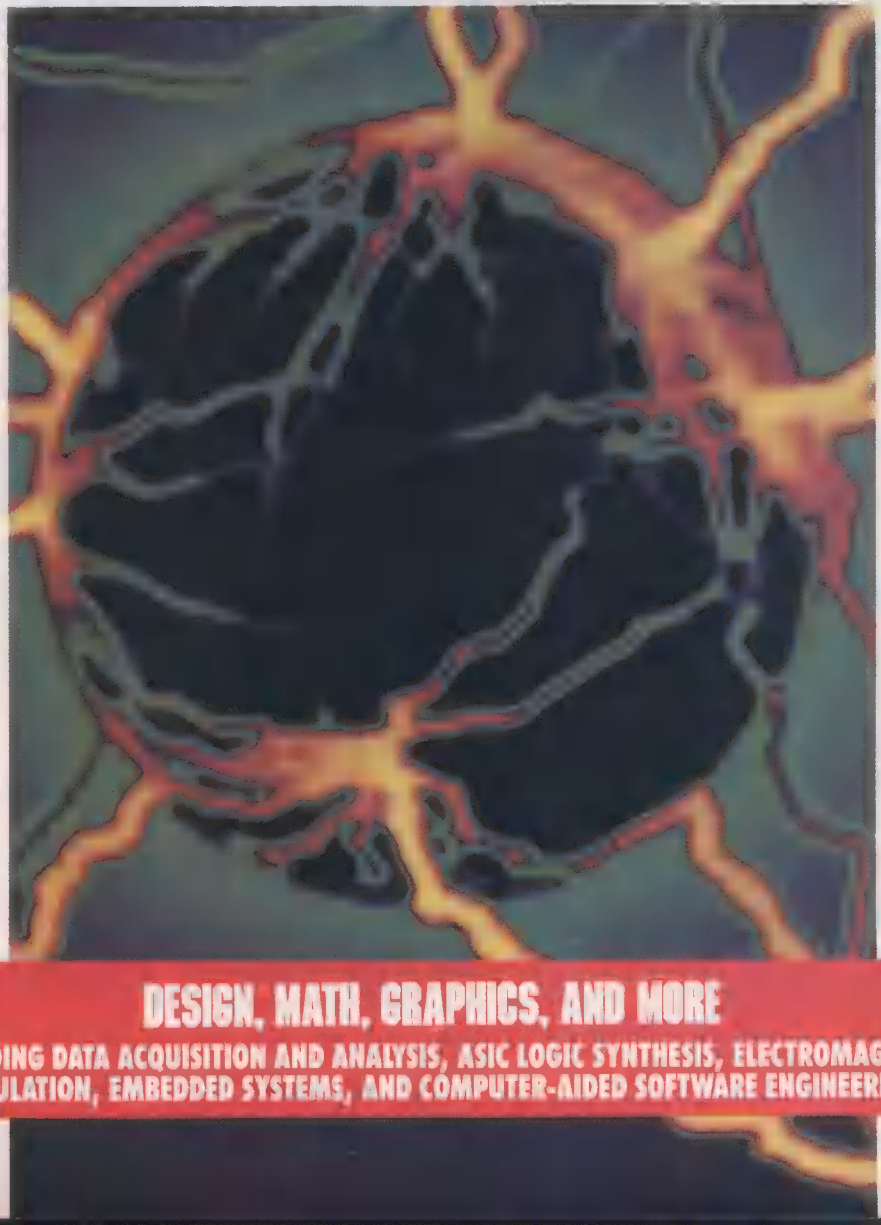

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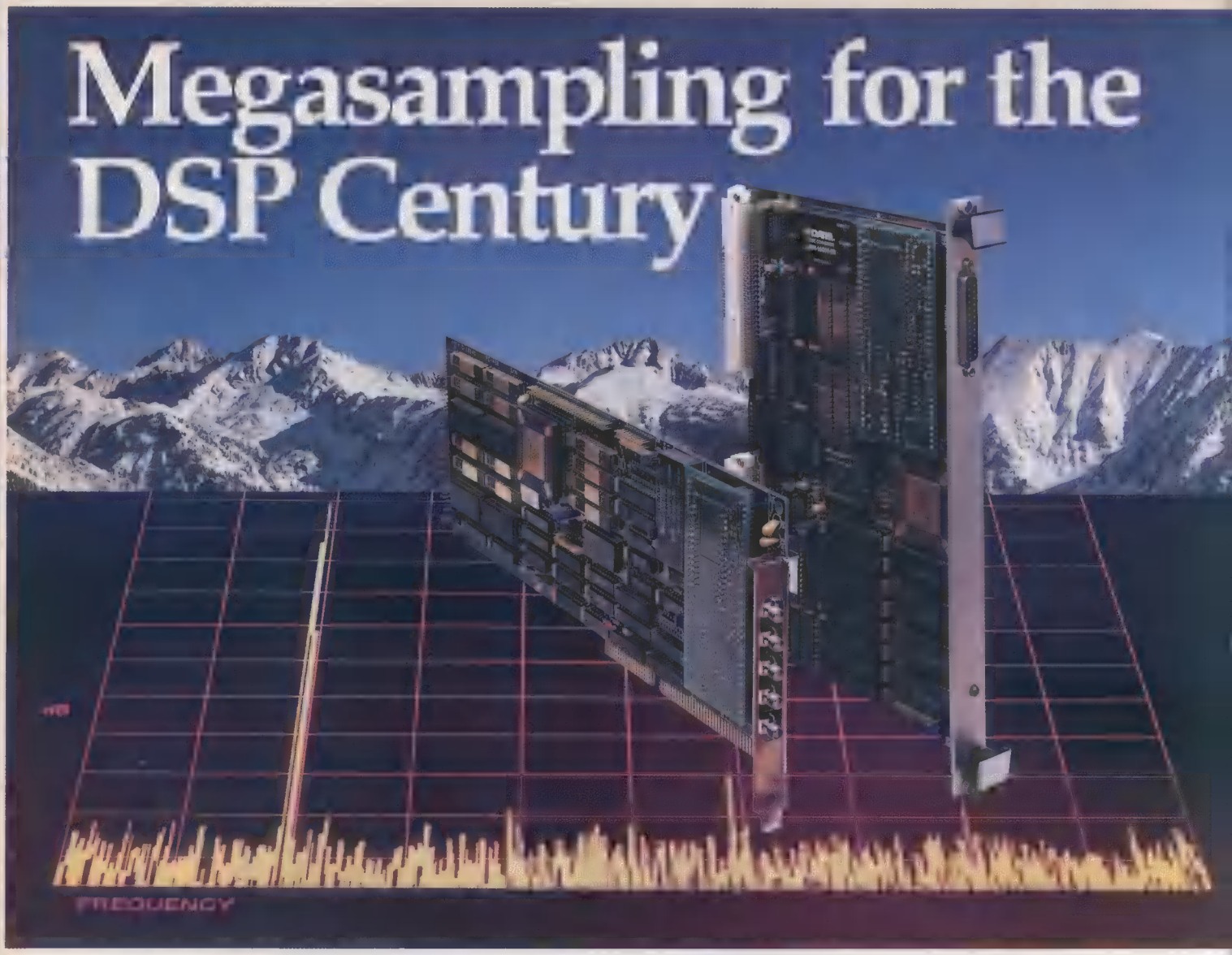

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GUIDE TO ENGINEERING SOFTWARE

His eyes glued to a workstation's display, a microwave design engineer meticulously studies an animation of electric field propagation in a microwave device. A few desks down the aisle, his colleague minimizes power consumption in her latest logic design of an application-specific IC, while a software engineer nearby edits an embedded-system code that was automatically generated from a block diagram just an hour earlier.

The use of electrical and electronics engineering software tools with these capabilities and more is on the increase. Last year the worldwide market for electrical engineering software sold by vendors in the United States alone exceeded US $960 million. That total is expected to increase this year by 10 percent to nearly $1060 million, according to Gisela Wilson, manager of computer-aided design, engineering, and manufacturing at International Data Corp., a market research firm in Framingham, Mass. Among the likely reasons for this growth is the increasing use of personal computers and workstations.

Furthermore, a 1991 independent study conducted by Erdos & Morgan/MPG, an international market research firm in New York City, showed that more than 81 percent of *IEEE Spectrum* subscribers use computers at work, and close to 84 percent of these use PCs and microcomputers, with more than 50 percent of the computer users employing workstations. Even more striking is the extensive use of scientific and engineering software—by 89 percent of all software users among the more than 1200 respondents covered in the study.

This second annual report on engineering software focuses on significant updates in electrical and electronics software for PCs and workstations in six leading areas: logic simulation for application-specific integrated circuits (ASICs); electromagnetic design and simulation; data acquisition, analysis, display, and technical reporting; math calculations and graphics for visualization; digital signal processors for embedded systems; and computer-aided software engineering (CASE).

The report also includes a table of *representative* packages and vendors in each area featured. *Spectrum* compiled the tables with help from the six expert authors of the articles included here, as well as an advisory board appointed for this report. In the tables, it is assumed, for brevity, that a package for an IBM Corp. personal computer will also work with IBM PC compatibles. Also, vendors listed often have other packages besides the one described.

For readers interested in obtaining additional information about the packages, an editorial and advertisers' index is appended. A "defining terms" section [p. 25] does just that, and "To probe further" lists sources of more in-depth information [p. 60]. ◆

Gadi Kaplan Senior Technical Editor

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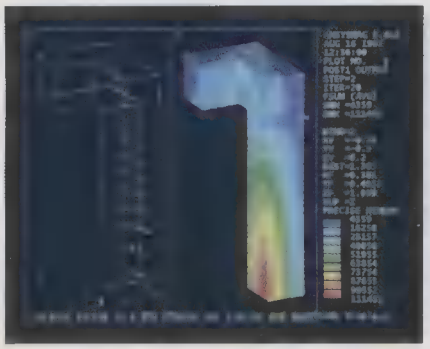
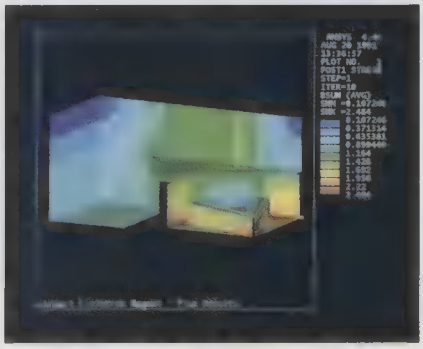


ANSYS magnetics was used by Stone and Webster Engineering Corporation with MIT Plasma Fusion Center to analyze the conductors, iron mass, and field in a MHD channel. Displayed are the Lorentz forces in a conductor.



Magnetic field analysis for a cyclotron magnet design was performed by the National Superconducting Cyclotron Laboratory, Michigan State University, using ANSYS magnetics to determine flux density levels.

A printer head linear actuator device was modeled by IBM Corporation to evaluate normal end axial forces on a sliding armature situated between two stators.

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Defining terms

2-D simulator: software that solves for the electromagnetic (EM) fields around a set of transmission lines (a computer bus, for example) that have a uniform cross section in the direction of propagation.

2.5-D simulator: software that solves for EM fields in structures composed of several layers of metal and dielectric, with vias between layers; the metallization may have any outline, but the enclosure has a rectangular cross section, for example, a microstrip spiral inductor with an air bridge crossover.

3-D simulator: software that solves for EM fields in structures containing conductors and dielectrics of any geometry in an enclosure of any shape, for example, a coax-to-waveguide transition.

Combinational logic element: one in which the output values are a function solely of the input values.

Computer-aided software (systems) engineering (CASE): the automation of software (systems) engineering principles and methodologies to the development of computer software (systems—where "systems" refers to both hardware and software). This typically involves diagramming tools, prototyping, specification, design, and verification checking.

Critical path: an electrical path that limits the maximum clock speed.

Embedded computer system: a computer system that is integral to a larger system whose primary purpose is not computational.

Emulator: hardware that replaces a microprocessor in a developmental system, allowing viewing and control of a developmental program as it runs.

Finite-difference method: a means of solving field equations in differential form by approximating them with a rectangular mesh and then finding the values of the scalar potential field at the grid points.

Finite-element method: a means of solving field equations in which the solution region is subdivided into smaller regions (elements) and a trial function is assumed across each element, so that a solution may be sought for the nodal values, which are the free parameters of the trial function.

Finite-state machine: a component that controls a sequential process and contains the current state of the process in a small number of registers.

Ground bounce: a shift in the ground reference potential of a digital IC when a fast transition in ground current causes a potential across the parasitic inductance of the package.

Moment method: the transformation of field equations in integral form into a matrix algebraic equation by discretizing the problem into small elementary cells and approximating the surface current on each cell.

Netlist: a circuit design description in terms of the structural elements and their interconnections.

Object-oriented methods/techniques: analysis and design techniques that model the requirements and resulting physical structure of a system with objects (which combine data and processes).

Repository: a standard database for the storage of all software development information.

Scan chain: a method by which the input of registers can be set—and observed—off chip or off board.

Sequential logic element: one in which the output values are a function of both the inputs and the data stored within it.

Simulator: for digital signal-processing code, a program that interprets that code on a host central processing unit.

Software engineering: the systematic approach to the development, operation, maintenance, and retirement of software.

Spectral-domain method: the Fourier transformation in two dimensions of field equations in integral form, so as to reduce the solution space to a set of ordinary one-dimensional differential equations.

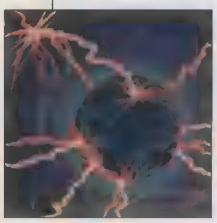
Static analyzer: a software tool that aids in the evaluation of a computer program without executing the program.

Structured (software) design: a disciplined approach to software design that adheres to a specified set of rules based on such principles as top-down design. (In this, a system's major components are decomposed into subcomponents, sub-subcomponents, and so on until the desired level of detail is achieved.)

Virtual memory: a feature allowing the storage of programs and data outside the computer's main memory, thereby enabling the running of larger programs than those using only the main memory.

Logic synthesis for ASICs

Vendors add power and convenience to tools that transform a functional spec and its timing into an application-specific IC



Though only a few years old as a commercial product, logic synthesis software already competes in quality of results with manual design—and, of course, far excels human efforts in speed. Meanwhile, synthesis tool vendors are developing the power and convenience of their offerings. Soon, tools will synthesize sequential as well as combinational logic. They will make key design decisions for the user, and they will perform formal design verification.

Logic synthesis software transforms a specification of a function and its timing into an application-specific integrated circuit (ASIC) such as a gate or standard cell array, programmable logic device (PLD), or field-programmable gate array (FPGA). The term "logic synthesis" is usually reserved for the processing of equations that are unstructured, or "random." When a circuit is structured, well understood, and easily specified—an adder, multiplier, or random-access memory, for example—designers prefer module generators to logic synthesizers. Module generators use a specification of a logic module (word width in bits, area, and delay limits) to select one of several previously characterized choices.

The basic techniques for logic synthesis were invented by researchers at IBM's Thomas J. Watson Research Center, AT&T's Bell Laboratories, the University of California at Berkeley, and the University of Illinois. Synopsis Inc. introduced the first commer-

(Continued on p. 32)

Robert Damiano
IBM Thomas J. Watson Research Center
Douglas S. Reeves North Carolina State University

Representative software packages for logic synthesis for application-specific ICs (ASICs)

Package	Company	Debut	Price, US $	Platforms	HDLs used	Schematic capture?	Target technologies	Comments
HDL Synthesizer and Optimizer	Cadence Design Systems Inc.	6/91	15 000; 35 000	Sun 4, IBM RS/6000, DECstation, HP 700	Verilog	Optional	ASICs, CMOS, biCMOS	Has unified library for simulation, synthesis, timing analysis, fault simulation; is integrated with backend physical design and layout tools; optimizes area and timing simultaneously
Exemplar Logic Synthesis System	Exemplar Logic Inc.	6/91	2000–40 000	Sun Sparcstation, IBM PC 386/486	Palasm, Boolean 1076, VHDL	Schematic generator available as option	ASICs, CMOS, FPGAs—Xilinx, Actel, Quicklogic, Plessey	Does architecture-specific optimization and mapping; uses industry standard interfaces; retargets FPGAs into ASICs for volume production; migrates PAL designs to FPGAs and other ASICs
Oasis 1.1	MCNC, Center for Microelectronics	1/91	500/600; 3000	Sun, VAX8600, DECstation, Convex-C1/2	Logic-III	No	CMOS	Optimizes for area, delay, testability; synthesizes finite-state machines into netlists; synthesizes data-path circuit hierarchically from descriptions of components; is integrated with automatic test generation and standard cell layout system
AutoLogic 7.0/1.3	Mentor Graphics Corp.	1988	34 900	Sun 3, 4; HP/Apollo 400, 3000, 4500, 3500, 4000	VHDL, M (optional), KISS/PLA/Boolean representations	Optional	CMOS gate array/standard cell, FPGA, full custom IC	Optimizes for area, timing, and power; is parameterized into complete top-down ASIC and IC environments (Idea Station, GDT Designer); migrates technology automatically; optimizes architecture-specific FPGA and synchronous and asynchronous states
Design Compiler family, HDL Compiler family, Test Compiler version 2.0	Synopsys Inc.	3/91	Start at 45 000, 20 000, 40 000	Sun, DEC, IBM RS/6000, HP/Apollo, Solbourne	Verilog, VHDL	No	CMOS, ECL, GaAs, biCMOS, FPGA	Optimizes for delay, area, and power of combinational logic, sequential circuits, and finite-state machines; quickly explores architectural alternatives; automatically designs for test and scan test generation
Frenchip	Teradyne Inc.	6/91	75 000 complete package	Sun	Mixed graphics and VHDL	Yes	CMOS	Synthesizes behavior of combinational, structured, and state-machine logic; uses specialized techniques for structured logic; optimizes for speed/area; synthesizes 100K-plus gates and test logic
Xilinx BLOX	Xilinx Inc.	11/91	2995 (PC), 4995 (Sparcstation)	Sun Sparcstation, IBM PC 386/486, Apollo, NEC	Graphical symbols	No	Xilinx CMOS, FPGAs	Optimizes for delay; includes module generator; synthesizes RAM, ROM

FPGA = field-programmable gate array HDL = hardware description language PAL = programmable-array logic

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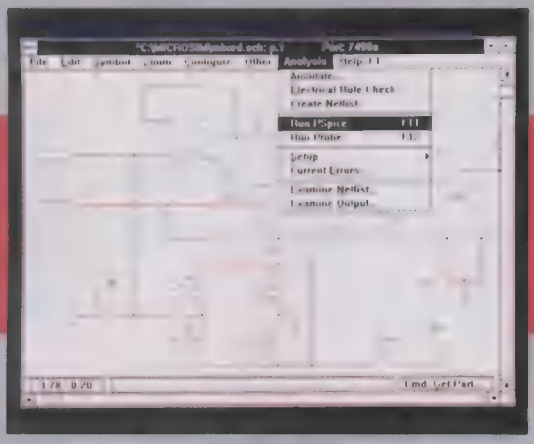
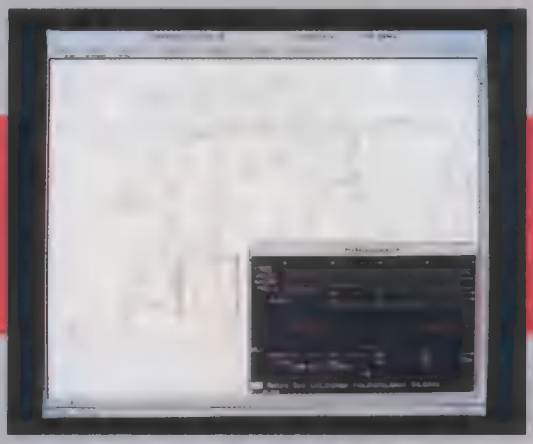


Schematics as a Windows 3.0 application



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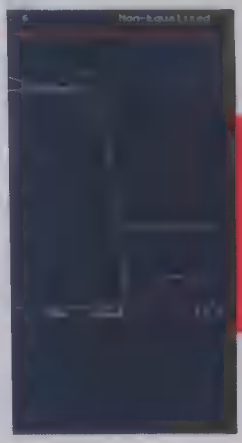

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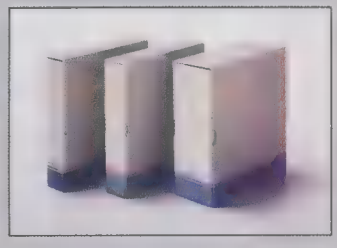

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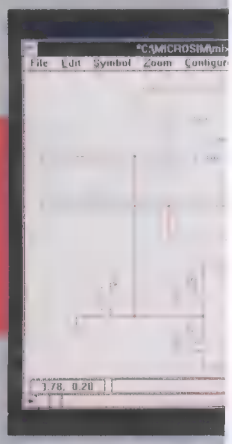

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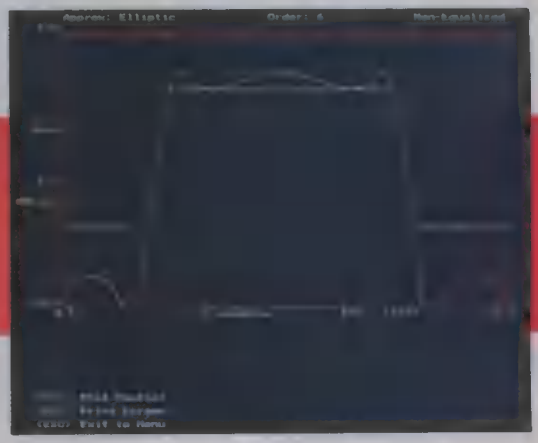
Performance Analysis: rise time and overshoot derived from multiple waveforms with stepped resistance



Bode plot in Filter Designer

can be tracked as a function of changing conditions (like temperature or model parameter values). Now it's easy to visualize trends in your circuit's performance by plotting quantities like delay versus temperature or pulse-width versus component value.

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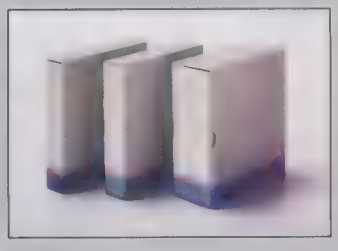

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Logic synthesis

(Continued from p. 26)

cial tool set in 1988, and has since become a leading vendor. There are now about a dozen companies offering tools for logic synthesis [see table, p. 26]. Sales of these tools now total about US $65 million.

MAJOR STEPS. Whatever the type of system, the major steps in logic synthesis are generally the same. If the input specification is for ■ finite-state machine, sequential optimization is used to collapse equivalent states and find ■ state encoding that minimizes the combinational logic to be generated. After this comes a set of technology-independent transformations on the combinational logic, designed to reduce the area of the circuit by eliminating duplicate or unused logic. The next step, technology mapping, creates ■ netlist in the ASIC technology specified by the user (CMOS or bipolar, gate array or field-programmable gate array, and so on). The usual final step involves refinements like fan-out correction, power optimization, and late timing correction.

Because most steps in logic synthesis are difficult, powerful heuristics are used. The results they generate are very good, but not necessarily the best possible. Even producing these nonoptimal results can consume much processing time for large circuits. The vendors of synthesis tools are competing to offer the tool that produces the highest-quality results on the largest possible size of circuit in the least computer time.

OPEN STANDARDS. Increasingly, hardware description languages (HDLs) are being used to capture the function and structure of a circuit and to simulate that circuit. The two major HDLs are Verilog and VHDL. Verilog was developed by Gateway Design Automation (now part of Cadence Design Systems Inc.) and marketed as ■ proprietary product. Cadence announced recently that Verilog will be made an open standard. In relinquishing control of Verilog—the most widely used HDL commercially—Cadence hopes that more vendors will develop products around it.

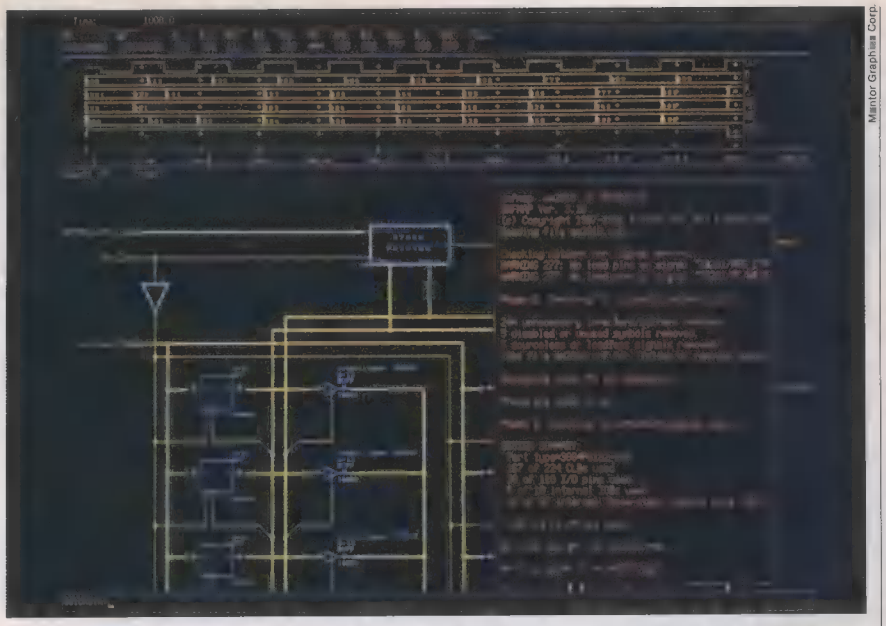
VHDL was developed in the mid-1980s as part of the U.S. Department of Defense (DOD) very high-speed integrated circuit (VHSIC) program. It has been adopted as IEEE Standard 1076. With strong support from the DOD and the advantages of standardization behind it, interest in VHDL is growing rapidly and the number of tools based on it is growing, too.

At present, logic synthesis is possible only for subsets of these languages. For example, both languages can express asynchronous sequential behavior, but almost all synthesis tools produce only synchronous sequential hardware. The user is allowed to specify the exact structure of a circuit (which is not synthesized) and the behavior of ■ circuit (which is synthesized). The behavior can be in terms of Boolean expressions, state transitions, and conventional flow-of-control statements (IF-THEN-ELSE or looping, say).

FOUNDRY PACTS. Technology mapping is a key part of logic synthesis; here, the design is targeted for a particular technology library. Each tool vendor works out agreements with fabrication foundries to characterize its library of cells. A major question for the customer, therefore, is whether the technology needed is supported by the synthesis tool.

Early tools were developed largely for CMOS technology, although recently introduced tools can also handle bipolar technology—emitter-coupled logic (ECL), for example. The rules for bipolar synthesis are more complicated than those for CMOS. Bipolar tools must accommodate bigger libraries, higher fan-ins, wired logic, and multiple voltage levels, as well as power optimization problems. Moreover, bipolar tools are not as mature as CMOS tools.

A rapidly expanding segment of the ASIC market belongs to PLDs and, in particular, FPGAs. The fast design turnaround time and low cost (in small volumes) of these devices make them ideal for many applications that used to rely on discrete components and



1. A schematic of a 1300-gate application-specific integrated circuit (ASIC) is being built graphically from large functional building blocks on Mentor Graphics' Autologic synthesizer. For example, the stack pointer block in this display is a finite-state machine with 10 states and 100 gates. After functional verification, the circuit will be mapped for implementation in Xilinx field-programmable gate array (FPGA) technology.

small-scale integration. As a result, several companies have jumped into the logic synthesis market for FPGAs and PLDs [Fig. 1]. Usually these new tools run on PCs and are inexpensive. All the same, few tools focus on the issues of interconnection routing and delay, which are important concerns in FPGAs. This area is ripe for development.

In minimizing circuit area, today's synthesis tools can produce results ■■ good ■■ those of manual designers. Getting the best results from synthesis at this point, even so, requires careful, informed use by the designer, since two different descriptions of the same function may yield, when synthesized, quite different results.

A designer, or ■ computer-aided design support staff, may "tune" ■ synthesis tool for particular priorities. Again, this calls for some understanding of the operating principles.

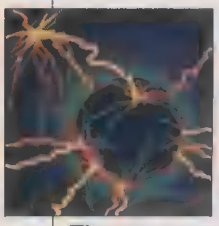
To optimize for speed, the user must specify arrival times of inputs and required times for outputs. Synthesis may select gates or may size buffers to achieve ■ given delay. In addition, critical paths may be shortened by duplicating logic; this results in less fan-out along the critical paths. Where possible, identical gates may be used at different power levels in order to improve timing.

TESTABILITY. Rather few synthesis tools guarantee that ASICs will be 100 percent testable. But under pressure from equipment manufacturers striving for higher quality, several synthesis tool vendors now offer elimination of redundant logic and creation of automatic scan chains—widely regarded as necessary for high fault coverage. Remaining challenges to ensure testability in-

(Continued on p. 62)

Simulating EM fields

As system frequencies rise, new and more powerful tools strive to keep pace by emulating more complex electromagnetic fields



Several new software tools for simulating and analyzing electromagnetic (EM) fields have appeared on the market over the past 12 months, and several older tools have reappeared in more powerful versions. These programs continue to help engineers visualize and manipulate EM fields and, thereby, to design products without the extensive testing and redesign formerly needed to accommodate unforeseen EM effects. The products that can be treated are diverse, including integrated circuits, printed-circuit boards, electromechanical devices, and high-voltage components.

Solving field problems remains highly computation-intensive, however. New engineering workstations have the speed and capacity to handle them better, but no revolutionary advances that greatly reduce computation time have appeared.

While some vendors and users have speculated optimistically about analyzing complex circuits completely with EM field solvers, a more realistic approach for the near term is to divide a problem into parts and apply EM software to the subproblems. Solving a large problem on a unit may be possible only when massively parallel or vectorized computers become more common in engineering laboratories.

In the meantime, the available tools are gratefully accepted by engineers for the insights they afford into design problems. Users can see the effects of design changes before building any hardware; they can develop high-speed digital and radio-frequency/microwave products that function properly from the outset in an increasingly cost-competitive environment. In digital circuit design, for example, cross talk, ground bounce, and package parasitic reactances can be addressed effectively by some newly introduced solvers. This is timely, as increasing clock rates aggravate these problems; today's 40–60-MHz rates will rise to 100 MHz in the next year or two.

Daniel G. Swanson Jr.
Watkins-Johnson Co.

At such speeds, the standard IC packages in use for decades can no longer be considered "transparent" to signals; instead, they strongly affect the pulses passing through them. Both old and new chip packages accordingly have to be analyzed for their EM effects.

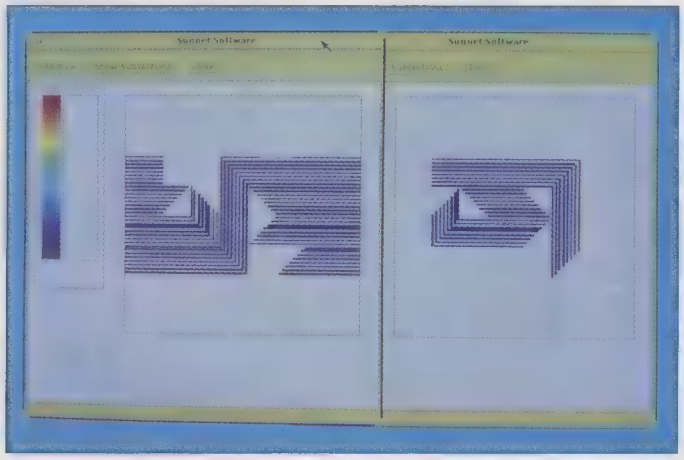
A new set of programs from Parametric Integrated Circuits Inc. relieves IC package designers of much of the frustrating and time-consuming chore of entering package geometries into an EM analysis system. The set, called ParICs, works with AutoCAD drafting software to generate complete three-dimensional models for IC packages and printed-circuit boards. The models may be wireframes (outlines only) or surfaced (filled-in walls). ParICs has direct interfaces to AutoCAD for documentation, Ansys for thermal and structural analysis, and Maxwell 3D for EM simulation. Parametric is developing custom interfaces to its geometric database for several simulator vendors, under contract.

Another boon to designers is newly offered direct links between EM solvers and Spice, the widely used circuit simulator. Although 2-D cross-section solvers have been applied to digital backplanes and buses for many years, the availability of a direct Spice link eliminates a tricky, tedious, and time-consuming manual conversion of EM simulator output into circuit simulator input.

For example, Contec Microelectronics USA Inc. offers an optional 2-D cross-section solver for ContecSpice that is based on spectral-domain analysis. It generates inductance, capacitance, conductance, and resistance matrices for an arbitrary cross section of uniform transmission lines. Solving problems with 32 to 64 lines appears to be practical with today's hardware and software.

Another solver-to-Spice link is available in HSpice by Meta-Software Inc. Meta-Software's 2-D cross-section solver is based on the finite-difference method. Solutions for up to three transmission lines are approximated with inductance-capacitance-resistance networks and fed to the HSpice simulator.

For more complex networks, 2.5-D solvers are needed. A 32-bit-wide, 8-bit–byte reversal network can be analyzed only with a solver like em from Sonnet Software Inc. [Fig. 1]. But, although em can easily generate multiport scattering (S) parameters for such a network, so far there are no analysis programs that are both suitable for digital designers and can use the data. Theoretically, a fast Fourier transform (FFT) can be done on the S-parameter matrix at each time step, but this computation-intensive procedure has yet to appear in a commercial analysis tool.



[1] In this simulation of a printed-circuit board for a 32-bit-wide, 8-bit–byte reversal network, two layers of a portion of the multilayer board appear. Colors indicate the current density in the lines; red is high, and blue is low. In the top layer (left), the triangles represent descending vias; in the next layer down (right), the triangles are ascending vias. The top line at left drives the network at 50 MHz. Because of cross talk, current appears in the eighth line from the bottom at left. Simulation is by Sonnet Software Inc.'s em.

COMMON FRAMEWORK. Large-scale digital design is best done with a three-tiered approach. In the first tier, the designer is dealing with block diagrams and usually needs from a field solver only rough rules of thumb about IC package performance and coupling between paths. In the next tier, the autorouting stage, when computer-aided design or engineering tools select circuit paths, the designer needs more detailed analysis, but speed is also important.

In the third and last tier, critical paths must be analyzed.

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Maxwell 3-D Field Simulator	Ansoft Corp.	1/91	18 000; 45 000	Sun 4, Sparcstation; HP; IBM RS/6000	Sun OS, HP-UX, Domain, AIX	Electric and magnetic fields; characterization of electronic devices	New material types in models; fully transparent meshing
Microwave Explorer 1.0	Compact Software Inc.	6/91	25 000	Sun, HP/Apollo, DECstation, IBM	Unix (and compatible)	Microwave	2.5-D solver with box mode extraction; X-Windows and OSF Motif graphical interface, incl. current distribution visualization
SI (Signal Integrity Analysis)	Contec Microelectronics USA Inc.	7/91	18 200–34 600	Sun, HP, IBM, IBM PC 386/486	Unix, DOS	High-speed digital, analog, and mixed-signal systems, ASIC, PCB and MCM; RF and microwave designs	Complete time-domain interactions of multiple coupled transmission lines and nonlinear electronic devices; 2-D electromagnetic field solver generating L, C, and R matrices for arbitrary geometry, unlimited number of conductors
EMSim 3.0	EEsof Inc.	1989	19 500	Sun 4, Sparcstation; HP/Apollo; IBM RS/6000, PS/2	Unix, OS/2	Microwave printed-circuit analysis, including nearest-neighbor coupling effects	Ten-times-faster simulation; partial structures such as circuit S-parameter files; transistors operating at bias; manufacturing statistics can be included
High Frequency Structure Simulator (HFSS)	Hewlett-Packard Co.	8/91	41 000	Sun, HP 300, 400, 700, 800; Apollo; DEC; IBM PC 386/486	HP-UX, Domain, PC-UX, Sun and DEC Unix	3-D simulator for machined components (e.g. waveguides); passive circuits (vias, spirals, air bridges)	Dynamic field solver now calculating effect of dielectric and metal losses; animation mode showing field propagation
MagNet 2D/3Dx 4.0	Infolytica Corp.	4/91	3000–70 000	Sun, HP/Apollo, IBM PC 386, DEC/VAX, Cray	DOS, Unix, VMS	Electromagnetics (motor, transformer, etc.), electrostatics (high-voltage transformer, etc.), high-frequency, microwave	3-D voltage-driven problems (for multiply-connected regions); fast-solution option; multiple simultaneous analyses; CAD interfaces
Amperes (3-D magnetostatics)	Integrated Engineering Software	1/91	8500 (lease)	Sun Sparcstation, IBM PC 386/486	DOS, Unix	Magnetic shielding, recording heads, medical diagnostic equipment, etc.	Based on boundary-element method (no finite-element meshing is required); IGES geometry file exchange format with CAD packages; multiple WHAT IF? scenarios through batch function
Linmic+ Vrs. 2.2	Jansen Microwave Ingenieurbüro	1/91	27 750	Sun Sparcstation, HP/Apollo, VAXstations	Sun OS, HP-UX, Aegis, VMS	Hybrid and monolithic microwave ICS	Hierarchical structure; 1-D to 3-D field-theory-based design (passive, active, noise); interactive in most functions
MSC/EMAS	MacNeal-Schwendler Corp.	1989	Call vendor	Sun, HP, Convex, Cray, DEC, IBM	Platform-compatible	2-D, 3-D statics, ac transients, eddy currents, microwave circuits, resonant cavities	2-D, 3-D absorbing boundary conditions; isotropic and anisotropic complex materials
HSpice H9007B	Meta-Software Inc.	7/91	3000–90 000	Sun, HP/Apollo, DEC, IBM, Cray, PC	VM-CMS, Sun OS, Unix, DOS, others	RF, microwave circuit design	Lossy transmission line analysis; network analysis
ParICs	Parametric Integrated Circuits—(Division of Ansoft Corp.)	1/91	995 per module	Sun, PC	DOS, Unix	Modeling of ICs and PCBs	Modeling in 3-D through dimensional inputs; models compatible with AutoCAD, Ansoft, Ansys formats; framework for package design
XTK	Quad Design Technology Inc.	1989	30 000–50 000	Sun Sparcstation, IBM RS/6000, MIPS, DG, SGI, HP/Apollo, IBM PC, DEC	DOS, Unix	Crosstalk and transmission line analysis	Ground bounce; model translation from Spice
BoardScan	Quantic Laboratories Inc.	5/90	17 000	Sun, HP/Apollo Intergraph, DECstation, MIPS	Sun OS, Aegis/Domain OS, HP-UX,Clix, Ultrix	Digital interconnects	Screening of PCB layouts for critical nets; interface to Greenfield; geometry library
em	Sonnet Software Inc.	1989	32 000	Sun Sparcstation, HP/Apollo, IBM RS/6000, DECstation, Cray	Unix	Microwave, analog, digital	Current distribution animation output; interface with Cadence and GDSII layout format
Ansys-PC/Magnetic	Swanson Analysis Systems Inc.	8/91	Call vendor	Compaq Deskpro, IBM PS/2, HP Vectra, NEC, IBM PC	DOS	Motors, transformers, transmission lines, actuators, permanent-magnet devices	2-D, 3-D capabilities for static and low-frequency analysis; automated design optimization

ASIC = application-specific integrated circuit MCM = multichip module PCB = printed-circuit board DG = Data General Corp. SGI = Silicon Graphics Inc.

Here, using a highly detailed, computation-intensive field solver is warranted. BroadScan and Greenfield from Quantic Laboratories Inc. and a suite of tools from Quad Design Technology Inc. can address all three of these tiers. A tighter integration of these tools into a common design framework is a challenge that lies ahead.

Designers of radio-frequency and microwave circuits face a similar situation: existing tools continue to improve and several new tools have been added to the repertoire, but no one electromagnetic simulator today will solve all problems. While 3-D solvers based on the finite-element method are the most general, 2.5-D solvers based on the moment method are more efficient for largely planar circuits such as microstrip, stripline, and coplanar waveguide. In some special cases, where several transmission lines of uniform cross section run in parallel, 2-D cross-section solvers are still the most efficient tool.

COMBINING FILES. The most prudent approach today is to solve small pieces of a large problem and use a linear circuit simulator to combine the S-parameter files from the subnetworks. For example, microstrip discontinuities like steps in width and T junctions (perhaps a small part of an amplifier, filter, or oscillator circuit) can be quickly analyzed as a function of frequency. The computed S parameters can be combined with analytical models for other circuit elements so that the complete circuit can be analyzed. Field solvers are particularly useful at millimeter-wave frequencies, a region where analytical models for transmission lines and discontinuities may be inaccurate or even nonexistent.

One newly improved tool is Jansen Microwave AG's Linmic+, which now combines 2.5-D analysis capability with 2-D. Linmic+ was the first microwave analysis program to offer an efficient 2-D cross-section solver based on the spectral-domain method. The supplier plans further enhancements, such as a specialized solver for coplanar waveguide circuits.

To its linear simulator Super-Compact, Compact Software Inc. has added a 10-strip model, based on the spectral-domain method, good for microstrip, stripline, and suspended stripline. The model was previously available in Compact Software's nonlinear simulator Microwave Harmonica.

A new entry in the 2.5-D electromagnetic simulator market is Compact Software's Compact Explorer. Like Sonnet Software's em, Compact Explorer can analyze mostly planar circuits with many dielectric and metallization layers and vias running between layers.

In addition, EMSim from EEsof Inc. is a 2.5-D simulator for microstrip circuits with air bridges. Although EMSim uses approximations that limit its upper frequency, depending on substrate thickness, it is fast and accurate when used as intended. A two-stage microwave monolithic integrated circuit (MMIC) amplifier with several large spiral inductors on the chip can be analyzed in about 6 minutes per frequency point.

ANIMATION. Hewlett-Packard Co. has added animation of field plots and conductor loss to its High Frequency Structure Simulator (HFSS). This powerful 3-D simulator can analyze such complex problems as a coaxial-cable-to-waveguide transition or a four-port waveguide junction. Although several other programs yield 3-D solutions for electrostatics or magnetostatics, HFSS is currently the only finite-element–based product that gives a 3-D full-wave solution and S-parameter output.

Sonnet Software's em has also added animation of conductor currents to its list of features. Em now solves faster and includes many new features in its geometry capture module, Xgeom.

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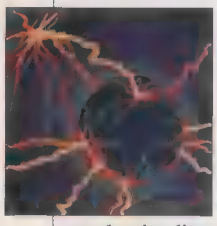
Data handling

Faster capture, extended compute-intensive analyses, and better visualization of the results are highlights of new software packages



Software packages for integrated data acquisition, analysis, display, and reporting are familiar elements of the engineer's toolkit. Useful for answering WHAT IF? questions, they are as at home on the production line as on the developer's workbench. This update reports on enhancements introduced since *IEEE Spectrum*'s Software Report of a year ago in products in this category [see selection of packages in table].

John L. Schmalzel University of Texas

Underlying these software advances is the steady rise in hardware performance. Package vendors are using this development to:

- Extend the capability of their products by adding compute-intensive analysis routines and by expanding support for DSP plug-in cards.
- Add to data record sizes by exploiting larger memory and disks.
- Acquire data faster.
- Enhance visualization by capitalizing on sharper display resolutions, as well as developing new ways of treating data.

The net increase in personal computer (PC) or workstation throughput also lowers the barrier to real-time performance, bringing new applications within reach of real-time solutions.

Broadly speaking, the platforms and operating systems supported by the vendors surveyed here fall into four groups: 80X86-based PCs, Apple Macintosh PCs, Unix workstations, and the rest, ranging from Digital Equipment Corp. VAXstations running VMS to supercomputers from Alliant Computer Systems Corp.

Of the four, the lion's share of support by the vendors under review is found for 80X86 DOS platforms, followed by Unix-based workstations. Some operating systems are represented hardly at all. For example, only Laboratory Technologies Corp. in its LabTech Notebook supports IBM Corp.'s OS/2.

One software addition to an IBM PC or compatible may well be Microsoft Inc.'s Windows 3.0. A few packages are available in a Windows version, and vendors are hurrying to take advantage of Windows' powerful graphical user interface (GUI). Windows-based applications will prove a boon to the successful integration of design, analysis, test, and documentation tasks, because the software makes moving data between applications much easier.

Representative data acquisition, analysis, processing and display, and technical reporting software

Package	Company	Debut	Price, US $	Platforms	Operating systems	Application	Most significant new features
BBN/Probe Rel. 2.1	BBN Systems and Technologies Corp.	6/91	13 750 and up	DEC VAXstations	VMS	A, P/D, TR	X Windows
GrafMaker	BV Engineering Inc.	1/91	195	IBM PC/AT	DOS	A, P/D, TR	Unlimited plotting, with support provided for 34 different pen plotters
SPW 2.8	Comdisco Systems Inc.	5/91	25 000 and up	DECstation 2100/3100; HP/Apollo; Sun 3, 4	Unix, Ultrix 4.1, Sun OS 4.1, Domain R10.3	DA, A, P/D	Options: MultiProx; Hardware Design System 1.5
Global Lab (Rev. 2.0)	Data Translation Inc.	6/91	1295–2585	IBM PC/AT	DOS	DA, A, P/D, TR	Acquisition of 16-bit data direct to disk in real time; customizable report-generation module
MathType 1.1	Design Science Inc.	4/87	249 (PC), 149 (Mac)	IBM PC, Macintosh	DOS/Windows, Macintosh OS	P/D, TR	Graphical interface; automatic equation formatting
DADiSP 3.0	DSP Development Corp.	8/91	895 and up	Sun, HP, IBM PC, DEC, Concurrent WS, NeXT	Unix, VMS, Ultrix, DOS	DA, A, P/D, TR	3-D and 4-D (3-D and color) graphics matrix and image processing
ESPS/waves+ Rev.4.1/2.1	Entropic Research Laboratory Inc.	7/91	8990	Sun, HP/Apollo, DECstation, IBM RS/6000, Convex, Solbourne, Sony (Risc), Concurrent 5000/6000	Unix	DA, A, P/D, TR	Interface customization via X Interface Generation (XIG); support for S-bus DSP boards
digiMatic	Famous Engineer Brand Software	4/91	229	Macintosh	Macintosh OS 6.02 or higher	A, P/D, TR	Recovery of underlying numerical data from printed technical graphs and charts
Seer-H	Galorath Associates Inc., Seer Technologies Div.	7/91	15 000/year lease	IBM PC	DOS	A, P/D, TR	Hardware development and production cost estimating; Windows 3.0
HP VEE-Test	Hewlett-Packard Co.	5/91	5000	HP 9000, S/300, 400, 700	HP-UX	DA, A, P/D	Graphical programming; powerful user interaction, data handling, analysis, display
Hypersignal Windows	Hyperception Inc.	3/91	795–2 995	IBM PC, XT/AT/386/486	DOS, Windows 3.0	DA, A, P/D, TR	Dynamic link library; dynamic data exchange support

(Continued on p. 40)

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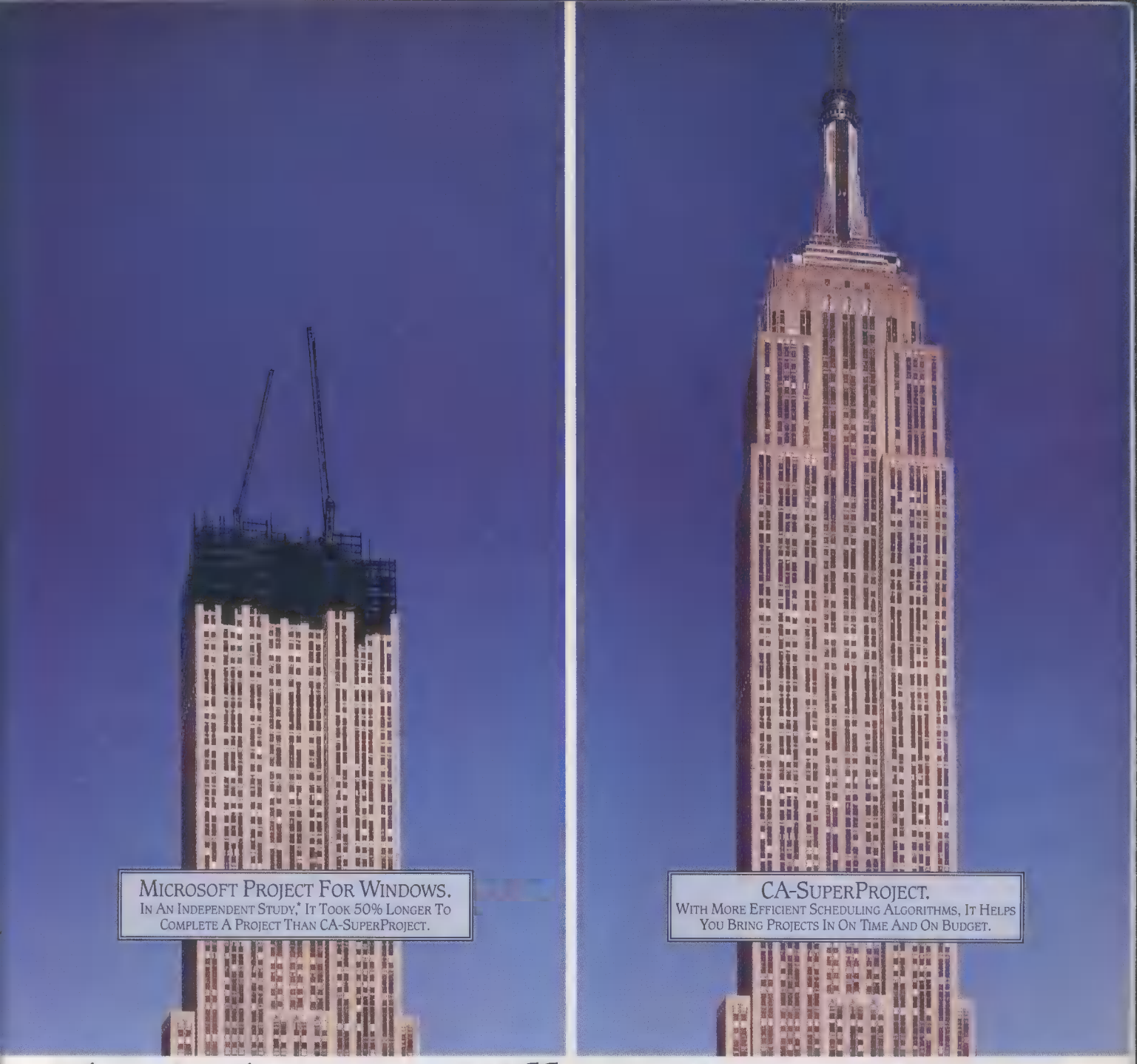

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* March 1991 study published by ISoft Decision, Inc., including CA-SuperProject 2.0, Microsoft Project For Windows, Symantec's Timeline 4.0, ABT Project Workbench and Scitor's Project Scheduler-5.

The higher power of 80386 and 80486 processors in the newer PCs also, of course, raises the performance level of the engineers' array of applications. And users of typical integrated data acquisition, analysis, display, and reporting tools can expect an improved complement of features.

Regardless of platform, data must first be brought into the machine environment. Vendors handle this with basically two techniques. Data acquisition cards that plug into the processor bus afford a variety of sampling rates and bits of conversion resolution. External instrument communication via low-speed protocols such as RS-232C or higher-speed protocols such as IEEE-488 and VXI (VMEbus extensions for instrumentation) handle interfaces to an almost unlimited number of instruments. With either technique, data records may vary in length from a few bytes to megabytes.

Once in the system, data records can be subjected to an impressive array of analysis routines—for example, standard digital signal-processing (DSP) routines such as convolution, correlation, and fast Fourier transforms (FFTs). Curve fitting for linear, polynomial, exponential, and other functions is widely available. Users also have access to libraries of standard statistical functions that are readily applicable to their data sets.

Whether it is raw data or what is left after being analyzed, users want to see results in pictorial rather than tabular form. All packages provide good visualization support for traditional two-dimensional plotting formats, fewer for three-dimensional and other plots.

Still, it is rarely enough simply to run through a few analyses and displays. Normally, some effort must be devoted to packaging results in an easy-to-read format. While most of the packages surveyed are not high-level desktop publishing tools, they will provide high-quality outputs on a variety of plotters and laser printers and can export a variety of file formats.

BETTER PC PACKAGES. A number of PC-based packages have undergone major upgrades during the past year. The LabWindows 2.0 released by National Instruments Corp. is a marked advance on its predecessor. It now provides a set of graphical interface development tools for the DOS environment comprehensive enough to implement full-

Representative data acquisition, analysis, processing and display, and technical reporting software (continued)

Package	Company	Debut	Price, US $	Platforms	Operating systems	Application	Most significant new features
Integrated Signal Analysis	Integral Signal Processing Inc.	1990	5900, 8100 (education, industry)	Sun, DEC	Sun OS, VAX/VMS	A, P/D	Estimation of quadratic transfer functions, wave-number-frequency spectrum
Matrix/System Identification	Integrated Systems Inc.	1983	1000 and up	IBM, DEC, HP/Apollo, Sun	DOS, VMS, Unix, Ultrix	DA, A, P/D, TR	DSP filter design; 2-D and 3-D graphics
EasySample	Intelligent Instrumentation/Burr-Brown	3/91	195	Macintosh II	Macintosh OS	DA	Data recorder and oscilloscope modes; four data file formats for export to analysis packages
TableCurve V 3.0	Jandel Scientific	7/91	495	IBM PC	DOS	A, P/D, TR	3318 built-in linear and nonlinear equations; two user-defined functions
Spawn	Jasco Systems Ltd.	3/91	995	IBM PC/XT/AT, 386/386SX, 486/486SX	DOS	DA, A, P/D, TR	Vector-oriented ($>10^9$ points) science and engineering spreadsheet; A/D, GPIB, DSP board support
Viewdac 2.0	Keithley Asyst	11/90	2495	IBM PC 386/386SX, 486/486SX	DOS	DA, A, P/D, TR	Arrays of 10^5 points; multitasking
Labtech Notebook for Windows	Laboratory Technologies Corp.	1991	1495	IBM PC 386/486, PS/2	Windows 3.0	DA, A, PD	Removal of MS-DOS memory limitations; multitasking
XRAY In-Circuit Debugger	Microtec Research Inc.	6/90	2200	IBM PC; Sun 3, 4; HP 9000; DEC VAX; HP/Apollo; DECstation 3100	DOS, Sun OS, VAX/VMS, HP-UX, Apollo Domain, Ultrix	DA (embedded MPU development), A, P/D	Functionality of in-circuit emulator at a fraction of the cost; no need to modify target application code
NDP-FFT/860	MicroWay Inc.	8/91	495	IBM PC 386/486 with i860-based card	DOS, OS/2, Sun OS, Unix	DA, A, P/D	Works with i860 chip, C++ and Fortran
TempleGraph 2.4	Mihalisin Associates Inc.	2/91	1290	Sun, Silicon Graphics	Sun OS, Irix	DA, A, P/D, TR	Color PostScript output link to Mathematica
LabWindows 2.0	National Instruments Corp.	3/91	1295–1495	IBM PC/AT, PS/2, EISA, or VXIpc-386 with 80286 processor	DOS 3.0+	DA, A, P/D, TR	Graphical user interface development tools; extended/virtual memory
IoCalc	Omega Engineering Inc.	2/91	550	IBM PC/XT/AT	DOS, OS/2	DA, A, P/D, TR	Menu driven with context-sensitive help; can be used to implement control loops, data loggers, filters, and more
Power Station	Operation Technology Inc.	1/91	Contact vendor	IBM PC	DOS	DA, A, P/D	On-line simulation of the power system; graphical user interface
DataScope	Paladin Software Inc.	2/90	190	IBM PC/XT/AT	DOS	DA, A, P/D, TR	ASCII data exportation; multiple concurrent sizeable windows
Signalys 3.0	Preston Scientific Inc.	8/91	1500	IBM PC/XT/AT/386/486	DOS	DA, A, P/D, TR (optional)	Compiler for custom programming; driver development kit

featured virtual instrumentation. In other words, the 2.0 user can build a graphical image of a prototype instrument complete with knobs, buttons, and displays that performs as if it were a real instrument. The new package adds support for extended and virtual memory models, as well as for the loadable object modules that help meet large development needs.

Other packages have also improved their GUI environments. For example, Atlanta Signal Processors Inc.'s DFDP3/plus has been equipped with pull-down menus, as well as having its signal analysis library expanded with 25 new functions. And Windows 3.0 support has been added to Labtech's LabTech Notebook and Scientific Software Tools Inc.'s DriverLinx.

WORKSTATIONS SET PACE. The workstation remains the pacesetter of the marketplace. Though its installed base is smaller than for PCs, it defines the next higher level of power above them. For many engineers, workstations have the highest processing power available in their workplace. The units are also influential because the features successful on them are inevitably ported to PCs as hardware and software power grow.

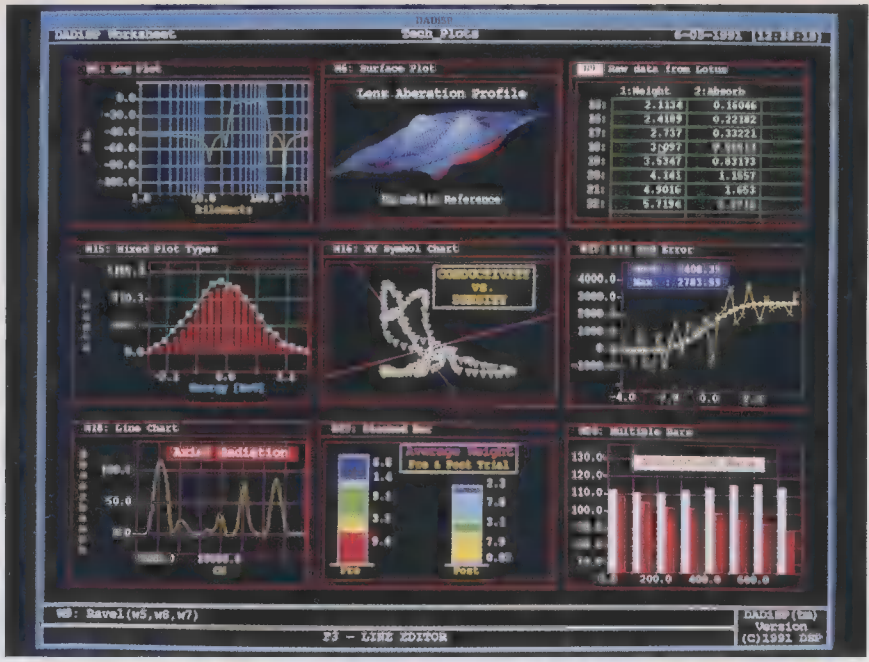
Signal Technology Inc. has continually improved its N!Power family, which is rooted in the earlier Interactive Laboratory System (ILS) package. Recent upgrades to N!Power include support for real-time data acquisition (at more than 150 000 samples per second), processing using plug-in DSP cards, and support for IEEE-488 instruments. These developments expand the data acquisition abilities of a mature package already armed with strong suites in analysis and display.

Hewlett-Packard Co.'s VEE-Test (Visual Engineering Environment) is a new product that provides data acquisition and processing. Capitalizing on HP's strengths in the instrumentation marketplace, and particularly on its numerous IEEE-488 and newer VXI offerings, VEE-Test supports more than 200 test instruments. This is a large number and, taken in combination with easy-to-use graphical features for data acquisition, analysis, and display, simplifies development of good-sized applications. Another upgraded package is Comdisco Systems Inc.'s high-end Signal Processing

Representative data acquisition, analysis, processing and display, and technical reporting software (continued)

Package	Company	Debut	Price, US $	Platforms	Operating systems	Application	Most significant new features
Huge Virtual Array Tools and Numerical Analysis Toolbox	Quinn-Curtis Inc.	8/91	300	IBM PC/XT/AT/386/486	DOS	A, P/D	Advances matrix math; stepwise multiple regression with virtual arrays to 100 Mbytes
DriverLinx	Scientific Software Tools Inc.	4/91	400	IBM PC/AT	Windows 3.0	DA	Windows-based drivers for data acquisition
IPLab 2.0	Signal Analytics Corp.	8/91	749 and up (options)	Macintosh II	Mac OS 6.0.5+	DA, A, P/D	Multiple programming languages; Q graph plotting of utility-to-graph analysis data
Hyper-signal-Macro Real-Time	Signalogic Inc.	7/91	989	IBM PC/AT/386/486	DOS	DA, A, P/D, TR	Macro language and DSP functions; DSP board device drivers
N!Power (DACS Module DACS!Power)	Signal Technology Inc.	3/91	3000–6000	Sun/Sparc, DECstation, VAXstation	Sun/Unix, RISC/Ultrix, VAX/VMS	DA, A, P/D, TR	Real-time data acquisition and processing by DSP boards; IEEE 488 device control and support
UtmostIIc	Silvaco International Inc.	1984	15 000–55 000	All Unix workstations	VMS, Unix	DA, A, P/D, TR	Macro model development; worst-case circuit analysis & design
HSA-RTDA	Sonitech International Inc.	7/91	3500–4500	IBM PCs, TMS 320C30-based DSP board	DOS	DA, A, P/D	Simple data acquisition and processing language; 16 analog input channels done concurrently
Speakeasy IV Zeta	Speakeasy Computing Corp.	8/91	2500–5000	IBM RS/6000; Sun 3, 4; Sparc; DECstation	AIX, Sun OS, Ultrix	A, P/D, TR	User-tailored graphical user interface; PostScript output
EasyPlot 2.2	Spiral Software	9/91	349	IBM PCs	DOS	A, P/D	User-written application files
Design-Ease 2	Stat-Ease Inc.	6/91	395	IBM PCs	DOS	A, TR	Ability to find optimal levels from up to 15 variables
S-Plus	Statistical Sciences Inc.	8/91	2800/1800	IBM PCs, Sun, DEC, HP, HP/Apollo, Silicon Graphics, Convex	Unix, DOS	A, P/D, TR	Over 600 statistical, graphics, and programming functions; object-oriented programming
Cyclic Spectral Analysis 2.0	Statistical Signal Processing Inc.	7/91	3495	Any with modern C compiler	Any with modern C compiler	A, P/D	Computation of all types of cyclic correlation and spectra; improved 3-D graphics
WorkBench PC	Strawberry Tree Inc.	8/90	995	IBM PC/XT	DOS	DA	Graphical interface; IEEE-488 support
Graftool 3.3	3-D Visions Corp.	1/91	495	IBM PC/AT/286/386 PS/2	DOS, Windows	A, P/D, TR	Graphical interface; formula solver
T³ Scientific Word Processing System 2.3	TCI Software Research Inc.	10/89	495	IBM PC	DOS	TR	Conversion to and from WordPerfect and to the TeX typesetting system
Axum Technical Graphics and Data Analysis	TriMetrix Inc.	9/90	495	IBM PC/XT/AT/286/386, PS/2	DOS	A, P/D	Additional programming capabilities, graph types in Version 1.02

A = analysis; DA = data acquisition; DSP = digital signal processing; EISA = enhanced industry standard architecture; GPIB = general-purpose interface bus; P/D = processing display; TR = technical reporting.



Graphs based on acquired data can be created in dozens of windows at once with the DADiSP 3.0 data-acquisition and analysis package from DSP Development Corp. Changes to a single window cause any dependent windows to be automatically recalculated and updated.

Workstation (SPW), which now includes an option for hardware design. Like VEE-Test, SPW also relies on icons.

DATA ACQUISITION. DSP processor boards are assuming new roles. They have long been a special feature of this class of software, especially for DSP algorithm development [see "Embedded systems software for digital signal processing," p. 52]. Now, however, DSP plug-in boards find favor as a convenient way to accelerate both data acquisition and data analysis.

Because the analysis algorithms executed on a DSP board and support for analog-to-digital (A/D) conversion must be tightly coupled, most DSP boards offer some form of piggy-back A/D card to bypass the host processor backplane. Sixteen-bit A/Ds that sample at 48 kHz are now common. New on many DSP boards is an ANSI S4.40-1985 standard interface. This allows interfacing to compact-disc players and digital audio tape recorders, thus extending real-time processing to audio bandwidth applications.

An irritant to many users is the software package that lacks instrument drivers for the equipment on hand. Remedies include referral to the factory for development of expensive low-level software instrument drivers or do-it-yourself driver development with the interface prototypes and support tools provided with the product. This places a premium on standard language interfaces and driver library support.

Consequently, features increasingly to be found in updated packages are support for standard languages and GUI interfaces. C, Fortran, Pascal, or Basic, as well as either the X.11 interface on Unix systems or Windows 3.0 on DOS systems, are now prevalent. Not only can this aid the construction of custom instrument drivers, but it is also a way to provide interfaces to other concurrent engineering tools.

ICONS FLOURISH. The migration to GUI environments entails a shift from text command strings to graphical images that represent operations, status, or other features. These images, or icons, are compact, meaningful representations. Several icon-based packages have been available for some time—for example, National Instruments' LabView running on Macintosh PCs, Comdisco's SPW on Unix workstations, and Hyperception's Hypersignal Workstation for PCs. New icon-based packages are being introduced, such as HP's VEE-Test. In addition, programs are being modified to support better graphical interfaces, as, for example, LabWindows.

Regardless of the package, results ought to be transferrable to other technical reporting and documentation tools. Simple screen dumps and high-quality plots remain indispensable, but users also want efficient transfer of text and graphics to desktop publishing packages. A number of interface techniques are used.

In a window environment, for instance, portions of a window can be copied from one application to another by means of a so-called clipboard. In a non-window environment, the interface is achieved through standard file formats, such as TIF (tagged image file format), which allow importing of results to a variety of word-processing and graphics packages. Another feature, now becoming common in updated programs, is support for Adobe's PostScript desktop publishing format. Not only does this assure high-

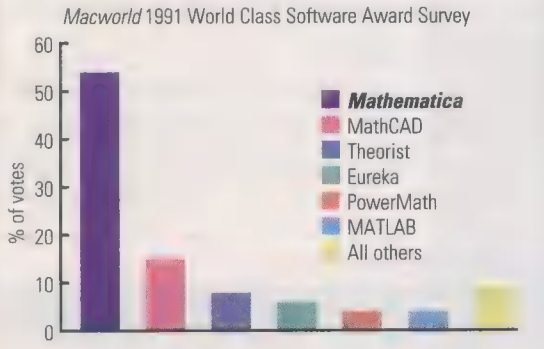
(Continued on p. 61)

Mathematica 2.0: the standard for technical computing

"The importance of the program cannot be overlooked ... it so fundamentally alters the mechanics of mathematics."
New York Times

***"Mathematica* has the potential to change the world of science at least as much as word processing has changed the world of writing."**
InfoWorld

***"Mathematica* is a startlingly good tool."**
Nature



Mathematica has also received best software/new product awards from:

Macworld, 1990-91
Discover, 1990
BYTE, 1989
MacUser, 1989
Business Week, 1988
InfoWorld, 1988

Available for PC, Macintosh, Unix, and VMS systems, *Mathematica* 2.0 brings a range of new capabilities to *Mathematica*, the proven leader in technical computing software. Interactively handling numerical, graphical, and symbolic computation at all levels, *Mathematica* 2.0 adds 50 percent more functions. These include sound generation, differential equations, external program communication, as well as enhancements to *Mathematica*'s built-in high-level programming language.

Mathematica has rapidly become the standard for technical computing, with more than a dozen textbooks, a quarterly journal, and several newsletters devoted to the system. *Mathematica* is in use at all of the 50 largest U.S. universities, all of the technical Fortune 50 companies, and most of the world's larger engineering firms. In fact, more than 100,000 technical professionals and students around the world are working with *Mathematica* every day.

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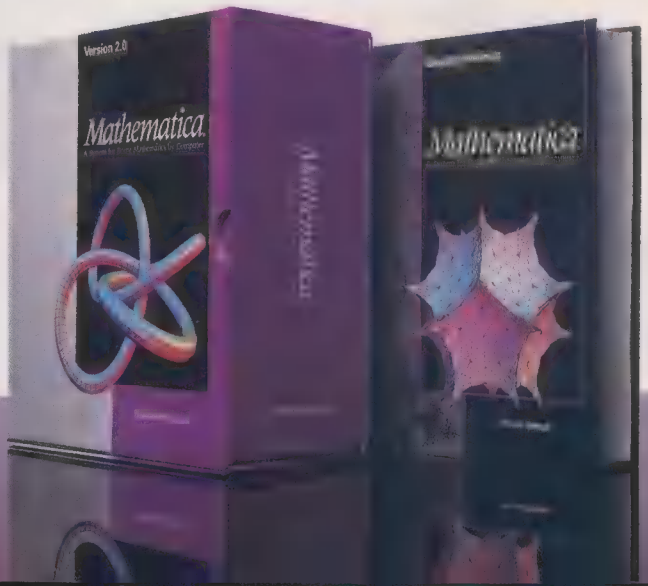
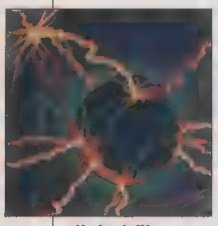
217-398-0700; fax: 217-398-0747; email: info@wri.com.

Wolfram Research (UK) Ltd., P.O. Box 114, Abingdon, Oxon OX13 6TG, United Kingdom
+44 (235) 550 440; fax: +44 (235) 550 445; email: info-uk@wri.com



Prepackaged math

Software upgrades bring much greater versatility to handling general mathematical problems and manipulating matrices



Not so long ago, the broad range of mathematical needs of a practicing engineer were poorly served by software packages. Although programs were available for specialized chores, such as designing digital filters or microwave resonators, this software was typically useless for more basic functions, like solving differential equations.

Fast gaining in popularity, today's more versatile engineering software packages may not be quite as fast or efficient as a special-purpose program, but they are more broadly useful. Many are also priced well under US $1000, although a few cost $10 000 or more [see table, below].

Kenneth R. Foster University of Pennsylvania

Although different packages have different capabilities, most fall into one of two categories. The first encompasses general mathematical software, which, in diversity of function and ease of use, can be likened to a Swiss Army knife. The second emphasizes mathematical manipulation of matrices. Both types can solve equations either numerically or symbolically and display results graphically. They require little or no programming by the user, but usually have features that let users create application programs to meet their individual needs.

Using one of these programs for the first time can be exhilarating. Tapping a few keys on even a modestly configured PC can expand a power series, evaluate an integral, take the transform of a function, fit data to a function, or solve some other intricate problem. In fact, enthusiasts say that these packages do for the engineer what spreadsheets do for the business professional.

POWER TO THE PEOPLE. Such features have been made possible on PCs by the machines' rapidly increasing power, particularly of those based on such microprocessors as Intel's 80386 and 80486, Motorola's 68020 and 68030, and the various reduced-instruction-set chips. These computers are not only quite fast, but they can address far more memory than their predecessors, by virtue of their 32-bit design. Most can also use virtual memory, a standard feature on most workstations and larger computers. (With virtual memory, much of a large program at any given instant is not actually present in physical memory, but stored on the hard disk, and moved into and out of the physical memory as needed to keep the program running.)

Now that high-capacity hard disks are also inexpensive commodities, it is economically feasible for PCs to run programs occupying tens of megabytes. This has led to an overlap of the workstation and PC markets,

(Continued on p. 49)

Representative new features in math and graphics (visualization) packages

Package	Company	Debut	Price, US $	Platform	Applications	Most significant new features
Tecplot Version 5	Amtec Engineering Inc.	10/91	649–3295	286 IBM PC; Sun, IBM, SGI, HP, DEC workstations	Engineering plotting and data visualization	3-D axes; multilayered plots
Gauss-386	Aptech Systems Inc.	1989	695	IBM PC	Statistical analysis; mathematics; econometrics; scientific analysis	Ability to create overlapping and tiled graphics windows; compatibility with Windows 3.0
DCS	Aurastar Information Systems Inc.	6/91	6000	IBM PC	Design and planning of distributed control systems	Immediate interactive response; multidisciplinary range, including communication, control, instrumentation, cost analysis
Chico Solver 2.2	Chico Software Co.	8/91	399	IBM PC, AT, PS/2	Nonlinear and differential equations, 2-D graphics	Identification, solution of subsystems; local and global optimization methods
MLAB	Civilized Software Inc.	9/90	995, 2995	IBM PC with DOS, PS/2 with AIX	General math and statistics; chemical kinetics; pharmacological modeling	Over 300 mathematical and statistical functions, including curve fitting with ordinary differential equations
PL2500	Eighteen Eight Laboratories	1/91	2495–5995	IBM PC, AT	High-speed math and logical computations on vectors, arrays, and matrices	2–3 times faster than earlier packages; library of 598 math functions; linkability to C, Fortran, and Pascal programs
ImageScale Plus	Electronic Imagery Inc.	7/91	1995–2995 and up	IBM PC, XT, AT, PS/2	Space, aerial, medical, industrial, inspection, agricultural, microscopy, signal processing, particle analysis, morphology, cell analysis	Unlimited macro combinations and number of steps; virtual image sizing, HDTV-based full-color file conversion
Aljabr 1.03	Fort Pond Research	12/90	249	All Macs (with 4M-byte minimum memory)	Symbolic and numerical math computations	Over 800 math functions and user options; user-extendability with programming and debugging tools; extensive documentation
Xmath	Integrated Systems Inc.	6/91	250 and up	Sun, IBM, and HP workstations, DECstation	Engineering data analysis; control systems design; signal processing	Object-oriented mathematics/data analysis, 2-D and 3-D graphics; integrated numerical programming/debugging

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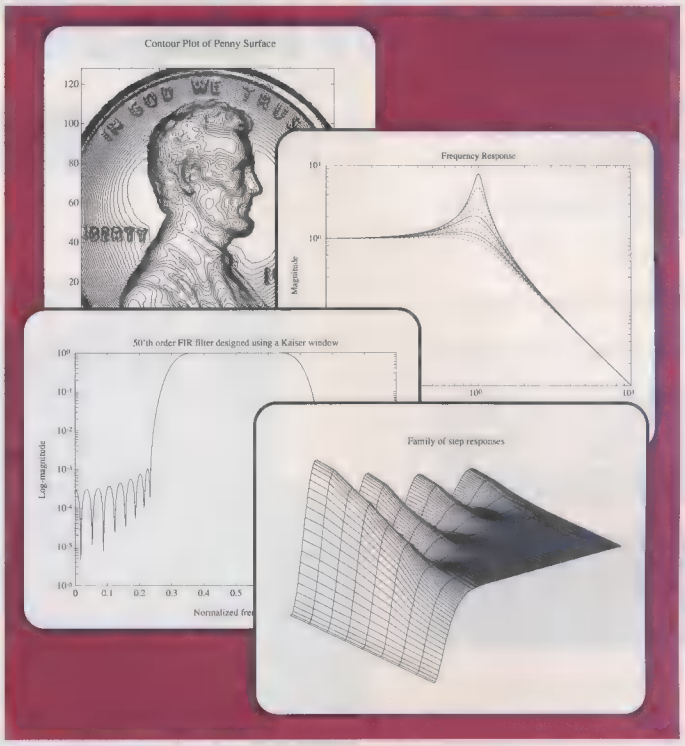

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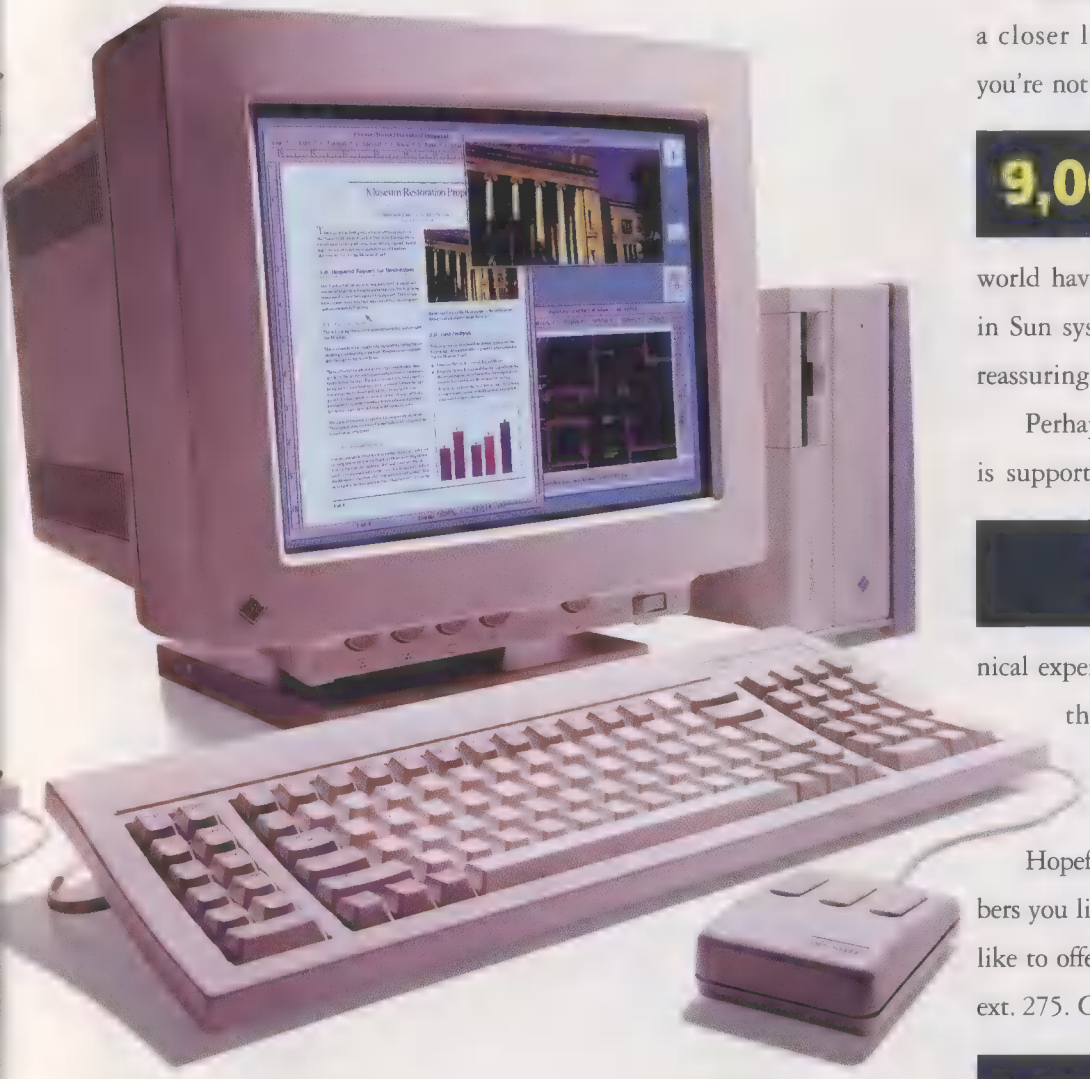

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Numbers, certainly. But a few more words and pictures, too.

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Representative new features in math and graphics (visualization) packages (continued)

Package	Company	Debut	Price US $	Platform	Applications	Most significant new features
SigmaPlot	Jandel Scientific	1985	495	IBM PC, XT, AT, 386, PS/2, Macintosh	Production of publication-quality scientific graphs	Reduced memory requirements and greater memory support for IBM version; release of Macintosh version
Matlab 3.5	MathWorks Inc.	1985	695 and up	IBM PC, AT; Macintosh II or SE/30; Apollo, Sun, DEC, and IBM workstations (also assorted super and mini-super computers)	General electrical, mechanical and chemical engineering; control systems design; signal processing, data analysis, modeling, system simulation	Optimization toolbox; ability to link external C and Fortran routines with Matlab programs
MathCAD 3.0	MathSoft Inc.	6/91	495	IBM PC; Macintosh; Sun and other workstations	Electrical, mechanical, and civil engineering; numerical methods; statistics	Symbolic math; optimized matrix computations
ACSL (Advanced Continuous Simulation Language)	Mitchell & Gauthier Associates Inc.	1975	2300–35 000	IBM PC, AT; Macintosh; most Unix workstations (also assorted super and minisuper computers, and mainframes)	Simulation, analysis, and visualization of many dynamic systems, including aerospace, automotive, chemical-process, and electro-mechanical systems	Ability to create Bode, Nyquist, Nichols, and root-locus plots; discrete state event finder
Axiom	NAG Inc.	10/91	1295–4995	IBM RS/6000, PS/2	Comprehensive math, with extensive symbolic-computation and graphics capabilities	Facilities for user-defined functions, data types, and macros; hypertext tutorials; 2-D, 3-D animation
PV-WAVE	Precision Visuals Inc.	1988	4500	All DEC, HP/Apollo 9000, IBM RS/6000, Sun, and SGI workstations	Test engineering; medical engineering; financial analysis; image and signal processing	16 mapping transformations; advanced-rendering library (3-D volume rendering)
Theorist 1.11	Prescience Corp.	2/91	399.95	Macintosh	Beginning to advanced mathematics for scientists, engineers, educators, and students	WYSIWYG interactive symbolic math and graphics; dozens of worked-out mathematical notebooks in package/disk
Math Advantage 4.0	Quantitative Technology Corp.	6/91	495–9900	More than 40, including Macintosh and PC families, Sun, HP, DEC, IBM, and i860-based workstations	Image and signal processing, seismology, engineering, electronics, education, military, and aerospace	96 subroutines added to library (634 total); embedded system support; now i860 assembly code library
N!Power Developer!Power	Signal Technology Inc.	3/91	4000–16 000	DEC-, VAX-, Sun Sparcstation; any X-server device	General data analysis and visualization for radar, sonar, speech, biomedical test and measurement, communications, other uses	Integration with real-time devices; for OEMs, system integration and end-users
Derive	Soft Warehouse Inc.	11/90	250; 289	IBM PC; HP 95LX palm-top; NEC 9801	General engineering and science education; symbolic math; calculus; differential equations; linear algebra	Programmability; advanced utility files
Transform 2.0	Spyglass Inc.	3/90	495; 795	Macintosh, SGI	Data analysis and visualization	Contour plots; surface plots
Macsyma	Symbolics Inc.	1982	795–1495 (academic); 995–2995 (commercial)	IBM PC 386/486; HP 9000; Sun 3, 4, Sparcstation; DECstation; SGI; VAX VMS/Ultrix; Symbolics 3600/Ivory	General scientific and engineering applications	Symbolics math and numerical math/graphics
Systat 5.0	Systat Inc.	10/90	895–1295	IBM PC, Macintosh, DEC VAX	Scientific EDA; engineering and quality control	Integration of 2-D and 3-D graphics and statistics; revised and expanded procedures for MGLH and quality control
VisSim 1.0	Visual Solutions Inc.	8/91	895	IBM PC running MS Windows	General simulation for biological, mechanical, chemical, and environmental research and engineering	Visual programming; nonlinear differential equation solver
Maple V	Waterloo Maple Software	1988	695	IBM PC, Macintosh, Amiga; most workstations	General math package, including symbolic math, numeric calculation, graphics, and programming	3-D graphics and mathematical enhancements
Mathematica 2.0	Wolfram Research Inc.	7/91	595 and up	IBM PC, Macintosh, DEC, HP/Apollo, NeXT, Sony, MIPS, Sun, Data General, Convex, SGI	General system and programming language for numerical, symbolic, and graphical computations in engineering, research, science, financial analysis, and education	Numerical solutions of differential equations; improved speed through compilation; sound feature allows audible monitoring of equation solutions

EDA = exploratory data analysis; MGLH = multivariate general linear hypothesis; N.A. = not available; OEM = original-equipment manufacturer; SGI = Silicon Graphics Inc.; WYSIWYG = what you see is what you get.

Prepackaged math

(Continued from p. 44)

to the benefit of both.

One result of this overlap has been the porting of workstation products to PCs—a transition to the competitive mass market that has compelled software vendors to improve the user-friendliness of their products. Graphical user interfaces, pull-down menus, mouse-driven commands, and other amenities that are required for success in the PC market are now commonplace.

ALGEBRA BY COMPUTER. Programs for symbolic manipulation of mathematical expressions have been around for several decades. Until the 1970s, they were used mainly by specialists and required a great deal of programming. Some, however, evolved into general-purpose mathematics packages, with extensive symbolic-manipulation, numerical, and graphics capabilities. Examples include Symbolics Inc.'s Macsyma (dating from the late 1960s) and Waterloo Maple Software Inc.'s Maple (1980).

Mathematica, a newer addition from Wolfram Research Inc., ambitiously combines computer algebra, numerical capabilities, graphics, and many other features in one large package. This year its vendors released a significantly enhanced new version for PCs and other systems (the MS-DOS version is reviewed on p. 73).

Macsyma, Maple, and Mathematica will run on high-end PCs or workstations equipped with several megabytes of physical memory. Derive, by contrast, is a small, highly effective algebra program that can run on PCs with as little as 540 Kbytes of memory. (This year Soft Warehouse Inc. released a version for a so-called palmtop computer, the Hewlett-Packard HP 95LX.)

MathCAD, another general-purpose program, has a scratchpad interface that combines equations, comments, and graphics on the computer screen. This information can be printed out to clearly document a calculation and its results. This year its developers, MathSoft Inc., released Version 3, which adds computer algebra (a subset of Maple) and other features. Version 3 runs under Windows and thus has its user-friendly command system.

MATRICES AND MORE. Other general-purpose math programs are based on optimized routines for manipulating matrices. With these programs, data sets are represented as matrices, and calculations are formulated as matrix operations on the data sets.

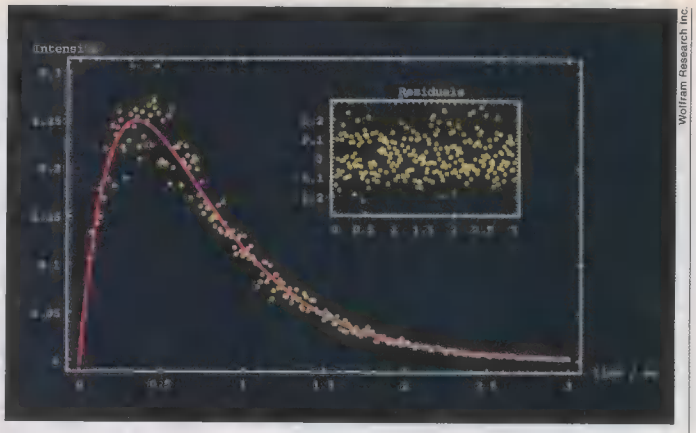
Several programs (Gauss, Matlab, MLAB, and Xmath, for example) take this approach. They include, in addition, graphics and many other capabilities. Matlab, in particular, has available an assortment of application programs called toolboxes. This year, MathWorks Inc. has updated the control-system and systems-identification toolboxes, which are useful for simulation and design of control systems. A new version of Matlab is ex-

pected later this year.

Xmath, another matrix-based program, is a new product from Integrated Systems Inc. for Sparc workstations (with versions for other workstations soon to come). It runs under X-Windows, the window-based operating system, and features elaborate graphics capabilities.

All of these matrix programs come bundled with application programs for tasks ranging from digital signal processing to numerical solution of differential equations, which vastly enhances their usefulness. Additional, customized applications can be written using the interpreted languages provided with most of these software packages.

Powerful mathematics packages let researchers analyze data points, for example, from an experiment typical of chemical kinetics, and instantly find the curve that best fits them.



WHAT TO LOOK FOR. Mathematics applications can be placed on a spectrum between number crunching (large or repetitive calculations) at one end, and exploratory analysis or one-of-a-kind calculations at the other. Users needing to do the former would probably turn to one of the matrix-based programs; for exploratory analysis one of the general mathematics packages might be preferable.

The general mathematics packages (Macsyma, Maple, Mathematica, MathCAD, and so on) are well suited for exploratory analysis. But they vary a lot in performance and features. Developing applications with a computer algebra program, for example, can be a lot of work, and users with such needs should carefully compare competing products.

For users with PCs, key factors to consider are memory requirements and processor speed. The large packages call for high-end systems, with several megabytes of physical memory and fast high-capacity hard disks (Macsyma, for example, demands 40 Mbytes of free disk space.) A Windows-based program, such as MathCAD Version 3, will run on an 80286-based computer, but too slowly for most users. It is best to try the programs before buying them, preferably on a system similar to one's own.

In addition to the general-purpose programs described above, many specialized products are also available. Some carry out specific calculations faster or more easily than the general-purpose programs.

Notable PC products in this category include Chico Solver, a new equation solving program from Chico Software Co. that allows easy numerical solution of systems of algebraic or differential equations (Chico Solver was reviewed in *IEEE Spectrum*'s May issue on p. 22). TableCurve (Jandel Scientific) and Minsq (MicroMath Inc.) are new programs for fitting data to functions. TK Solver Plus (Universal Technical Systems) is a general-purpose program based on a highly efficient method for numerically solving systems of equations.

ABOUT THE AUTHOR. Kenneth R. Foster (F) is associate professor in the department of bioengineering, University of Pennsylvania in Philadelphia. ◆

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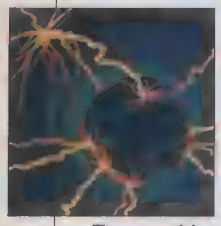
Circle No. 236

Embedding DSP

A proliferation of development tools for digital signal processing attack problems in this kind of system design



In some ways, the engineer who designs systems around digital signal processor (DSP) chips has a tougher job than his colleagues who design around conventional microprocessors.

For one thing, DSPs are usually based on the so-called Harvard architecture, a dataflow type that can be more difficult to work with because it relies on multiple data buses and a more complicated instruction set. Then, too, although the signal-processing system designer, like his colleagues, has at his disposal software and hardware development tools to edit, compile, assemble, link, load, and debug software programs, some DSP chips are not supported by compilers for high-level languages, like C.

Furthermore, esoteric DSP algorithms, such as those for spectral analysis, correlation, and adaptive filtering, can be tricky to implement, especially on a fixed-point processor where roundoff error is a major concern.

REDUCING COSTS. Fortunately, there is a lengthening list of DSP development tools on the market that accelerate the design and development of systems with embedded DSPs. These tools—both hardware and software—can also slash development costs by letting the engineer focus on a specific application rather than the myriad details of the programming task itself. Among these personal computer (PC)-based packages, filter design and implementation programs predominate.

Like conventional microprocessors, DSPs must be programmed. The vast majority now in use are fixed-point (scaled integer) DSPs and are typically programmed in assembly language. But floating-point processors, usually programmed in C, are rapidly attracting a following as their hardware and software development costs decline (it is generally easier to program in C than in a DSP assembly language).

To support their products' architectures and instruction sets, most DSP chip manufacturers sell assemblers and linkers. Often, these tools are also resold by companies offering high-level DSP design software packages.

HIGHER-LEVEL HELP. While a developmental program is running, designers can use higher-level tools—debuggers, simulators, and emulators—to help provide insights into the program's execution and flaws. The DSP chip makers themselves generally sell these tools, sometimes with special-purpose hardware to support them.

Usually, that hardware support is an emulator that replaces the DSP chip in the system being developed. Emulating the DSP's functionality in real time, it allows the user to view internal registers and memory, set breakpoints, disassemble code, watch interrupt handling, and look at port inputs and outputs.

Beyond this basic tool set for fundamental system development, other DSP software tools can be extremely useful for designing, simulating, implementing, and testing systems with embedded DSPs. With them, designers can manipulate waveforms for analysis, design filters, and even develop and simulate complete systems and algorithms, for example.

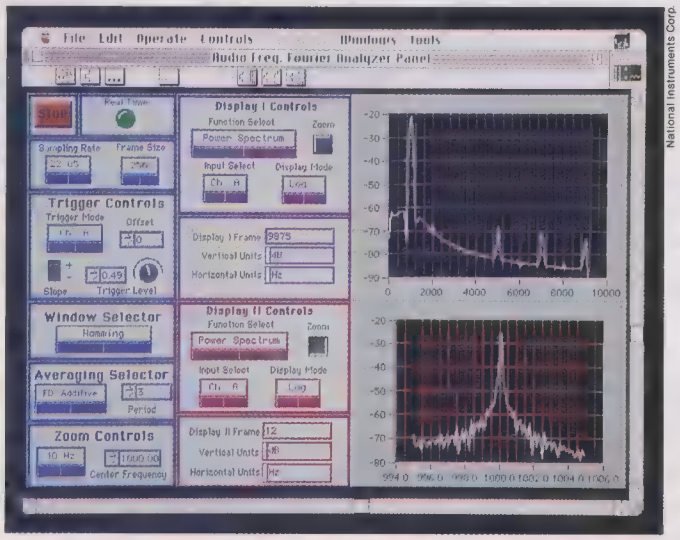
The computer platforms they run on fall into three groups: Macintoshes; IBM PCs and compatibles; and workstations, such as the Sun 3, Sun 4, Sparcstation, Hewlett-Packard/Apollo, and DECstation. Not surprisingly, the PCs enjoy the widest variety of software packages, while (again, no surprise) the workstations run the most powerful and most expensive programs.

Another critical factor in considering software tools is the type of DSP chips supported. Those having the widest range of available tools are the Texas Instruments DSP320C25 and DSP320C30, the AT&T DSP16 and DSP32C, the Motorola 56001 and 96002, and the Analog Devices 21XX and 21020 series. (For the NEC P77220 DSP processor, however, the only available tools are from Hyperception Inc.)

TWOFOLD SUPPORT. Both software and hardware design support is available for these DSP chips. Some software packages include code generators that produce ASCII DSP assembly language files that can be assembled and linked into the user's main program running on the digital signal processor. Since these code generators are specific to a DSP chip, it is important to indicate the exact chip on which the program is to run.

Hardware support is also available, in the form of accelerator boards with specific DSP chips. Available for all three classes of computer platforms—personal computers, Macs, and workstations—the boards plug into an empty slot on the computer bus and run the DSP programs independently of the host central processing unit or host memory. They are useful for proof-of-concept prototyping prior to custom hardware development.

Many software packages also permit the user to develop a DSP program and then compile, assemble, link, download, and execute it directly on a plug-in board. Some boards, too, also include analog input/output capability to interface to the outside world of sensors, transducers, microphones, and the like. Many debuggers work with these plug-in boards and I/O devices to



National Instruments Corp.

Two signals can be analyzed and manipulated at once with National Instruments Corp.'s Audio Frequency Fourier Analyzer, which couples a Macintosh II workstation with hardware for digital signal processing and custom graphics software.

Bruce C. Mather
Southwest Research Institute

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permit setting breakpoints, viewing processor registers, and monitoring chip-pin states in real time.

Such features are invaluable when tuning a complicated DSP system. However, ■ note of warning: sometimes the software tool supports only certain standard DSP operations on the accelerator board, such as performing a fast Fourier transform or filtering, and uses the host CPU for the rest of the DSP algorithm. This may preclude real-time operation of the DSP algorithm since the host CPU, generally ■ conventional microprocessor, typically cannot execute DSP algorithms at real-time speeds.

USER INTERFACES. Many, if not most, DSP development packages have roots in the original IEEE Digital Signal Processing software set—all written in Fortran over ■ decade ago and still available on magnetic tape. When converted for execution on single-user systems like PCs, they were recoded (often in C) and a user interface was added. Little of the core filter-design code has changed since those early days, but improved user interfaces and more sophisticated libraries and graphics are available in later versions of DSP software packages.

Companies that have recently upgraded their software tools include Signal Technology Inc., the makers of ILS, which has enhanced N!Power (DSP Module) with a block diagram user interface, code generators, runtime mode under X-Windows, and advanced DSP algorithm libraries. Another company, Momentum Data Systems Inc., has released DSPworks and QEDesign 1000, which run on Macintoshes, PCs (under Windows 3.0), and the Sun 4.

Hyperception has introduced Hypersignal-Windows with Block-Diagram, an icon-based DSP algorithm descriptional method. SignaLogic Inc., ■ spinoff of Hyperception, has added a DSP macro-language interface to Hyperception's Hypersignal workstation to permit automating a DSP algorithm within the Hypersignal environment. Atlanta Signal Processors Inc. has upgraded its DFDP product with an entirely new graphical user interface, improved filter-design cycling, and laser printer and PostScript output support.

DSP Development Corp. has released Version 3.0 of its popular spreadsheet signal-processing package, DADiSP, which is available for PCs and many workstations [see table, p. 38]. National Instruments Corp. released LabView DSP Developer Toolkit for the Mac in August to aid DSP system developers. And Comdisco Systems Inc.'s Signal Processing Worksystem, probably the most sophisticated DSP development system on the market, has added an option called MultiProx, with which DSP algorithms may be partitioned among several parallel DSP processors [p. 38].

BLOCK DIAGRAMS. Today there is ■ big push for block-diagram algorithm development, an innovative way of describing ■ DSP algorithm that permits rapid redesign of the system to reduce programming errors. Such

Representative software tools for embedded digital signal processing (DSP)

Package	Company	Debut	Price, US $	Platforms	DSP chips supported	Type of tool	Most significant new features
ADDS-210XX-DSW Development Software	Analog Devices Inc.	8/91	995, 2195 with compiler	PC, Sun 4	Analog Devices ADSP-21020	C, A, L, DSPL, S; (separate) E, D	Optimizing C compiler, validated by Plum-Hall suite; simulator, GUI with reconfigurable windows
BUG-56	Ariel Corp.	1989	495 (AT)	IBM PC, AT, Sun Sparcstation, VME, HP, Mac, NeXT	Motorola DSP56001	D	Graphic viewing of memory contents; debugging with processor running in real time; support of up to four DSP devices concurrently
DFDP3/plus	Atlanta Signal Processors	4/91	1045, 1195 with CG	IBM PC, AT	TI TMS320 family, AT&T DSP32	FD, CG	Pull-down menus and flexible data entry; 25 new signal analysis functions
Monarch DSP Software	Athena Group Inc.	6/91	595, 994 w. adaptive filters; 694 w.CG	IBM PC, AT, 386	AT&T DSP32C, Motorola 96002, TI TMS320C3X	FD, CG	Adaptive filter enhancement package; code generation via macro preprocessor; many signal system-analysis functions
DSP1600 support tools	AT&T Microelectronics	6/91	1500	IBM PC 386; Sun 3, 4; VMS	DSP1600 series	A, L, S, E, D, DSPL	Integrated windowing environment for source code development and hardware emulation at 33- and 25-ns cycle time
DspHq	Bittware Research Systems Inc.	9/90	495–795	IBM PC, AT, 386, PS/2	AT&T DSP32C	E, GUI	Real-time graphics and algorithm design; sample source code available for spectrum analysis

diagrams represent a signal flow with each block portraying a particular DSP operation, such as filtering, convolving, switching, modulating, and so on.

These blocks are often represented on a PC or workstation screen as graphical icons that can be "zoomed" and tailored—to filter-design specifications, say. Hierarchical blocks can be constructed from lower-level DSP operations, such as fast Fourier transforms, and replaced with a single icon.

When graphically linked on the computer screen—much like subroutines in a conventional programming environment—the blocks hide implementation details; the difference is that pictures replace the lines of code in conventional programming.

A secondary benefit of such computer-aided design products is that the block-diagram layout itself can become part of the system documentation—provided that the package has a utility that converts the block diagram into a standard-format file. Products equipped with such an interface are LabView-2 by National Instruments for the Mac, Hypersignal-Windows Block-Diagram by Hyperception, and DSPlay XL by Burr-Brown Corp. for the PC.

The Signal Processing WorkSystem by Comdisco Systems and N!Power (DSP Module) by Signal Technology are also block-diagram–oriented development systems that run on workstations from DEC, Hewlett-Packard, Sun, and other vendors.

A FINAL CHECKLIST. When selecting DSP development tools, system designers should consider the following questions (at minimum): does it run on my development platform—my hardware *and* operating system? Do I need, and does the product support, a code generator for *my* DSP chip? How comprehensive is the available library of DSP routines? Is there a DSP simulator available that runs on my development platform? Can I write my own routines to hook into the development environment, particularly for block-diagram–oriented systems?

Last but not least: will these tools be cost-effective? Most likely, the answer to this last question will be yes.

ABOUT THE AUTHOR. Bruce C. Mather (M) is a senior research engineer in the advanced training concepts section of the Automation and Data Systems Division at the Southwest Research Institute in San Antonio, Texas. A specialist in digital signal processing, he is currently developing new hardware for implementing virtual-reality systems on low-cost training platforms. He received his electrical engineering degrees from the University of Illinois in Urbana. ◆

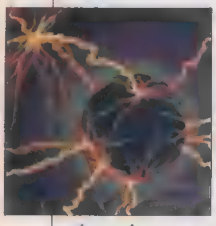
Representative software tools for embedded digital signal processing (DSP) (continued)

Package	Company	Debut	Price, US $	Platforms	DSP chips supported	Type of tool	Most significant new features
Hypersignal Windows	Hyperception Inc.	1/91	795–2995	IBM PC 386/486	ADSP2000, 2101, 21000; AT&T DSP32, 32C; M'la 56001, 96002; TI TMS32010, 320C25, 320C30	DSPL, S (limited), FD, CG	Package designed for Windows 3.0; dynamic data exchanges for inter-application communication; block-diagram DSP design
QEDesign 1000	Momentum Data Systems Inc.	6/91	895 (PC), 4200 (Sun)	IBM PC; Macintosh; Sun 4, Sparcstation	Analog Devices, AT&T, Motorola, TI, Samsung	FD, CG	Interface to N! Power; support of Windows 3.0; filters can be designed by graphical manipulation of poles and zeroes
DSP56KCC	Motorola Inc.	10/91	709	IBM PC 386; Sun 3, 4; NeXT	Motorola DSP56000/1	C, A, L, D	ANSI-compatible; full optimization capabilities
LabVIEW DSP Development Toolkit	National Instruments Corp.	8/91	2995	Macintosh	NB-DSP230X, TI TMS320C30	C, A, L, DSPL, D	Combination of graphical programming with development software for the NB-DSP230X and Analysis Accelerator boards for Macintosh
DSP Source Code Interfaces for Hypersignal-Macro DSP Software	SignaLogic Inc.	7/91	795 (per DSP chip)	IBM PC AT, 386/486	ADSP-210X; AT&T DSP32C, DSP5600X, DSP9600X; NEC 7720; TI TMS320C2X/3X	DSPL, FD, CG	Optimized assembly-language routines; real-time interrupt and processing structures
N!Power (DSP Module DSP!Power)	Signal Technology Inc.	3/91	2000–5000	Sun Sparcstation; VAXstation, DECstation; any X-server device	Motorola DSP56001; AT&T DSP32C; TI TMS320C30	C, DSPL, S, FD, CG	Extendable block diagram (Icon); object-oriented programming; linkage of X-Windows displays to DSP boards
DSP Designer 1.2	Zola Technologies Inc.	7/91	495–995	Macintosh Plus, Mac II	All Motorola DSP chips	FD, CG, GUI	Custom language incl. system modeling, waveform creation, and display; integrated software/algorithm development under Apple's Mac Programmer's Workshop

A = assembler; C = compiler; CG = code generator; D = debugger; DSPL = DSP library; E = emulator; FD = filter design; GUI = graphical user interface; L = linker; M'la = Motorola; S = simulator.

Automating software development

Redefining CASE as computer-aided systems *engineering may be necessary as packages take on system analyses*



The CASE industry is in a state of flux. Even the meaning of CASE is changing. Originally an acronym for computer-aided software engineering, it has grown to denote computer-aided *systems* engineering, so as to refer to hardware as well as software.

The most basic form of CASE means automating software development. Traditional CASE tools automate structured or object-oriented techniques, using diagrams and textual specifications to define system requirements, model system relationships, define a system's behavior, and specify the architecture for its software implementation. Recently, however, CASE tools have also been used to handle design issues like hardware modeling and specifications; several of these are included in the software packages now offered [see table].

Andrew Topper Foresite Systems

Designers of a typical data acquisition system, for example, might select some of the CASE tools listed in the table to handle various phases of their system design. (In each phase shown, a CASE tool and its manufacturer are suggested in parentheses.)

- Analysis: creation of models that represent the hardware and software; for example, the physical points where data are collected and routing paths (Teamwork/4.0 by Cadre Technologies Inc.).
- Logical design: specification of the physical characteristics and architecture for the software (RDD-100 Release 3.0 by Ascent Logic Corp.).
- Physical design: specification of the tasks of each hardware module; for example, the handling of interrupts of incoming data or the use of a hardware description language (StateMate by i-Logix).
- Code generation: generation of software code from the specifications (Matrixx/SystemBuild V2.04 by Integrated Systems Inc.).
- Manufacturing: transfer of hardware description into computer-aided engineering data from which chips, printed-circuit boards, and other hardware can be manufactured (SES/workbench 2.0 by Scientific & Engineering Software Inc.)
- Testing: simulated tests conducted to verify that the system behaves according to the specifications (TCAT, Release 8.2, by Software Research Inc.).
- Maintenance: statistical analyses and studies of WHAT IF? scenarios on existing systems (C Development Environment by Interactive Development Environments Inc.).

In the past year an important issue—integration between CASE tools—has become the topic of interest for most developers and users of CASE products. Perhaps the biggest drawback to the current CASE packages is inadequate integration of analysis, design, code generation, and testing tools. Some packages that claim to pass information from the design phase to the programming phase provide support for data structures and variables only, and not for the equally important structure and module

Representative computer-aided software engineering (CASE) packages

Package	Company	Debut	Price, US $	Platforms	Operating system	Software language support	Hardware language support	Most significant new features
RDD-100 Release 3.0	Ascent Logic Corp.	8/91	33 000	Sun, Sparcstation; Apollo; DEC; Mac II	Unix, Mac OS	Smalltalk 80	None	Dynamic verification facility; user documentation
Teamwork/4.0	Cadre Technologies Inc.	6/91	Contact vendor	Sun, DEC, HP, HP/Apollo, IBM, DG	OS/2, VMS, Unix	Ada, C, C++	None	C, Fortran reverse engineering; generation of test cases from structured analysis and statistical design models; simulation of structured analysis and real-time models
Cradle	CGI Systems Inc.	1989	12 500	Sun, Sparcstation, HP/Apollo, DEC	Sun OS, Unix	Ada, C, Pascal	None	Support for DEC; document composer; configuration management; enhancement; global import/export facility
MacAnalyst/ Expert 3.1	Excel Software	9/91	1595	Macintosh	System 6.0, 7.0, A/UX 2.0	Language independent	Language independent	Real-time extensions to structured analysis
Power Tools	Iconix Software Engineering Inc.	1985	Contact vendor	Macintosh, PC, Unix-based workstations	Mac OS, DOS-Windows, Unix-Motif	Ada, C, C++, Cobol, Fortran, Pascal, Prolog, and others	None	Enhanced multiuser dictionary and repository; enhanced graphical editors
IST-I	Illgen Simulation Technologies Inc.	5/91	Contact vendor	PC AT	DOS	Ada, C, Fortran	None	Software verification and validation

(Continued on p. 58)

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Representative computer-aided software engineering (CASE) packages (continued)

Package	Company	Debut	Price, U.S. $	Platforms	Operating systems	Software language support	Hardware language support	Most significant new features
StateMate	i-Logix	1987	60 000 for all 4 tools	Sun, Apollo, DEC, IBM RS/6000	Unix, Sun OS, Ultrix, VMS	Ada, C	VHDL, Verilog simulation and synthesis	Panel graphics editor; Verilog output simulation and synthesis
Matrixx System-Build V2.04	Integrated Systems Inc.	7/90	31 500	Sun Sparcstation, HP/Apollo, DECstation, VAXstation, IBM RS/6000	Unix, VMS, Aegis, Ultrix	Ada, C, Fortran	None	Graphical editor and simulator for hierarchical system design; automatic code generation from block diagrams
C Development Environment	Interactive Development Environments	6/91	3000–20 000	Sun Sparcstation, DECstation, HP9000	Unix (Sun OS, Ultrix, HP/UX)	C	None	Reverse-engineering of existing C code into structure charts; code generation
Object-Maker 2.0	Mark V Systems	8/91	8000	Most common platforms	DOS, Unix, System 7	Ada, C, C++	None	Capture of relationships between objects in problem space; mapping of notations and methods consistently with the design mode
Smartsystem	Procase Corp.	1/91	8750; 1750 per module	Sun 3, Sparcstation, DECstation, IBM RS/6000, MIPS	Sun OS, Ultrix, AIX, MIPS	C	N.A.	IBM RS/6000 platform support; enhanced user interface; new metrics module
SES/workbench 2.0	Scientific & Engineering Software Inc.	2/91	36 000	Sun, HP, IBM RS/6000	Unix	All	VHDL	Animated debuggers; interface from software through pictures
TCAT Release 8.2	Software Research Inc.	8/91	Depends on hardware	Most Unix and Unix work-alike workstation systems	Unix	Ada, C, C++, Cobol, Fortran (F77), Pascal	N.A.	C++ language adopted; X-Windows graphical-user interface for OSF/Motif
TurboCASE 4.0	StructSoft Inc.	3/91	995	Macintosh	Mac OS	Language independent	N.A.	Structured design; object-oriented analysis and design supports added
Requirements Tracer	Teledyne Brown Engineering (a Division of Teledyne Industries Inc.)	1/91	11 000, first user; 6500 per additional user	Sun, Apollo, DEC, IBM	Unix, Ultrix, Domain SR10, AIX	C	N.A.	User-defined requirements fields; automatic traceability; customized-report and matrix capabilities
ASA & Geode	Verilog Inc.	1989	25 000	Sun, DEC, HP/Apollo, IBM RS/6000	Unix, Sun OS, VMS, Ultrix	Ada, C	N.A.	Requirement analysis and SDL-based design tool with simulator and Ada and C code generator

DG = Data General Corp.; N.A. = not applicable; SDL = specification and description language—recommended by the CCITT for designing real-time systems.

description and flow of control.

CASE REPOSITORIES. In a move to address the integration issue between CASE tools, Digital Equipment Corp., IBM Corp., and Hewlett-Packard Co. have attempted to provide their own "standards" for CASE repositories. These will allow CASE tool vendors to write interfaces to a standard for communication that most (if not all) other tools will share.

When announcing its Cohesion, DEC defined it as an environment for developing, deploying, and managing software for information systems or embedded systems. Under Cohesion, all types of software development will be supported for VMS and Ultrix operating systems employed by DEC workstations as well as for some non-DEC platforms. Eventually Cohesion will provide tools for the entire system life cycle, along with documentation and communication tools.

The initial implementation of Cohesion products will be in VMS environment, with future support planned for Ultrix.

IBM's CASE strategy for technical or real-time and embedded systems software development is based on its AIX (Advanced Interactive Executive) operating system and the RISC System/6000 (RS/6000) hardware platform. The offering supports most traditional real-time structured methods as well as a number of object-oriented techniques.

Minimum requirements for IBM's technical CASE are AIX V.3 for the RS/6000 and AIXwindows Environment/6000. The company has allotted a wide variety of development tools to its technical CASE environment.

A DISTRIBUTED ENVIRONMENT. The SoftBench package available from HP provides a platform for CASE tool integration under a distributed, Open Software Foundation (OSF) Motif environment. Part of the HP CASEdge strategy, SoftBench uses X-Windows System, version 11. Currently, it supports development in Fortran, C, and C++, and it includes a program editor, builder, debugger, static analyzer, and development manager.

All the SoftBench development tools can be tailored to specific preferences, and version and access control can be implemented within the SoftBench. CASE tools in the SoftBench environment communicate over a network, sharing a common user interface and an integrated help facility. SoftBench currently runs on the HP Series 300 and 800 platforms under HP-UX and on the IBM RS/6000 series.

As part of its technical CASE strategy, IBM has recently adopted SoftBench. Many vendors in the table are also active under the SoftBench program.

Another form of CASE tool integration that has also been strengthened in the past year is the link between tools that help automate software development functions and those that automate hardware development tasks.

On the hardware side, many CASE

(Continued on p. 62)

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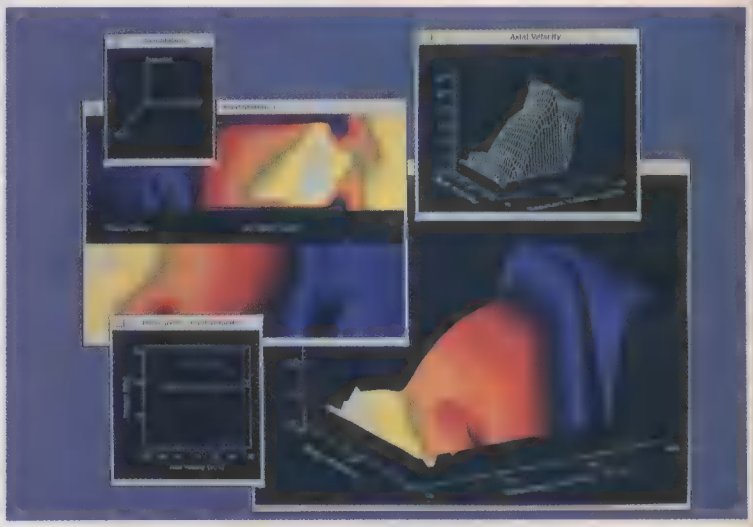

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To probe further

LOGIC SYNTHESIS FOR ASICs. The annual Design Automation Conference (DAC), cosponsored by the IEEE, presents papers, tutorials, and panel sessions on such topics as high-level synthesis, synthesis and delay testing, and technology mapping. The next conference will be held in Anaheim, Calif., June 8–12, 1992. For information, call 303-530-4333.

The IEEE International Conference on Computer-Aided Design (ICCAD) consistently devotes three or four sessions to synthesis. The next conference will be held Nov. 11–14 in Santa Clara, Calif. Contact the IEEE Computer Society at 202-371-1013.

For proceedings of the most recent DAC and ICCAD meetings, call the IEEE Service Center's Customer Service Department (445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331) at 1-800-678-IEEE or 908-981-0060; fax, 908-981-9667. The *IEEE Proceedings* for February 1990 is a special issue on advances in logic synthesis.

Aart J. de Geus explores the basics in "Logic synthesis speeds ASIC design," *IEEE Spectrum*, August 1989, pp. 27–31.

ELECTROMAGNETIC DESIGN AND SIMULATION. A good introduction to numerical methods for electromagnetics is *Computer-Aided Analysis and Design of Electromagnetic Devices* by S. R. Hoole (Elsevier, New York, 1989). The book gives examples of magnetostatics for rotating machinery and electrostatics for high-voltage insulators and transmission lines.

Numerical Techniques for Microwave and Millimeter Wave Passive Structures, edited by Tatsuo Itoh (John Wiley & Sons, New York, 1989), covers transmission lines and planar antennas. Some computer source code is included in simple demonstrations of the numerical methods.

Numerical Methods for Passive Microwave and Millimeter Wave Structures, edited by Roberto Sorrentino (IEEE Press, New York, 1989), is an excellent collection of reprinted articles for RF and microwave engineers.

George D. Vendelin describes software packages for microwave circuit design in "Evaluating nonlinear models for microwave GaAsFETs," *Spectrum*, September 1990, pp. 48–50.

A more detailed introduction to the boundary element method (BEM) can be found in *The boundary element method for engineers* by C.A. Brebbia (Pentech Press, London, 1984, revised edition).

DATA ACQUISITION. A standard for a high-speed backplane instrumentation bus structure is in development by an IEEE Computer Society working group as project P. 1155. Based on VXIbus specification 1.4 by the VXIbus Consortium (the latest version), the standard is to be available in 1992.

A working knowledge of fundamental concepts and methods of data analysis is provided in "Engineering data analysis using the PC," an IEEE self-study course, Product no. HL0409-3. Contact the IEEE Service Center (details above).

MATH CALCULATION AND GRAPHICS. The monthly *Journal of Symbolic Computation* has many articles on symbolic manipulation of mathematical expressions, and has published extensive descriptions of major computer-algebra programs. It is published by the Academic Press Ltd., 24-28 Oval Rd., London NW1 7DX; (44+1) 267 4466.

Several books exist on Mathematica. Particularly useful is its manual, *Mathematica: A System for Doing Mathematics by Computer*, by S. Wolfram (Addison-Wesley, Reading, Mass., 1991, 2nd edition).

Next January, Prentice-Hall, Englewood Cliffs, N.J., plans to initiate an academic software and textbook program built on the student edition of Matlab. Contact the College Marketing Division at 201-592-2158 or MathWorks Inc. at 508-653-1415, ext. 417.

An excellent text on numerical methods is *Numerical Recipes* by W. H. Press *et al.* (Fortran version, Cambridge University Press, New York, 1989).

EMBEDDED SYSTEMS SOFTWARE FOR DSP. Two volumes in Prentice-Hall's "Analog Devices Technical Reference Books" series are R. J. Higgins' *Digital Signal Processing in VLSI* (1990) and *Digital Signal Processing Laboratory Using the ADSP-2101 Microcomputer* (1991) by V. K. Ingle and J. G. Proakis.

An upgraded, color-graphics version of an earlier package that provides hands-on experience with signal processing on an MS-DOS PC is ILS-IEEE Signal Software, Version 6.0, product No. HLO443-2. Contact the IEEE Service Center (details above).

CASE. Computer aids to system engineering are among the topics discussed in the IEEE video course "Computer-aided systems engineering," Product No. HV0087-7. As before, contact the IEEE Service Center. An introduction to CASE is provided in *CASE I-S Software Automation* by Carma L. McClure (Prentice-Hall, 1989). A review of CASE tools and their use in the development of information systems is presented in *Information Systems Development: Principles of Software Engineering and CASE* by Albert F. Case Jr. (Prentice-Hall, 1986). ◆

Acknowledgments

In preparing this special focus report, *IEEE Spectrum* called on many experts. We are especially indebted to the individuals listed below for their advice and guidance, although their identification with the report should not be construed as their endorsement of any opinions or products covered in these pages, nor of the accuracy of the statements made in the articles.

The advisers for this report were: Laszlo A. Belady, chairman and director, Mitsubishi Electric Research Laboratories, Cambridge, Mass.; Guy Johnson, coordinator of graduate programs, department of information technology, Rochester Institute of Technology, Rochester, N.Y.; Hugh C. Lauer, senior research scientist, Mitsubishi Electric Research Laboratories; Ted G. Lewis, professor, computer science department, Oregon State University, Corvallis; Paul W. Oman, assistant professor, computer science department, University of Idaho, Moscow; Judith M.S. Prewitt, president and chief scientist, Paxx Group, Germantown, Md.; and Rob Rutenbar, associate professor, department of electrical and computer engineering, Carnegie Mellon University, Pittsburgh.

Data handling

(Continued from p. 42)

quality output of graphics and multiple-font text, but it provides another route for moving results between packages.

In any single package, the complexity of the functions being offered can be overwhelming. The would-be user should therefore place a premium on the vendor's provision of training and support. Experience has shown that the level of support after the sale correlates closely with how effective the user finds a package. Most vendors supply some form of free telephone support, software update subscription services, training programs, and consulting.

The power of integrated software tools also opens the door for their use as the basis for product development. Turnkey development and licensing arrangements are issues that must be discussed with prospective vendors.

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Software development

(Continued from p. 58)

products are adding support for block diagrams or a hardware description language (HDL) for modeling and designing hardware components. Some products in this category can also generate the IEEE-1076 standard HDL for very high-speed integrated circuits (VHSIC), or VHDL, from specifications. When properly integrated, VHDL code may drive any standard computer-aided engineering (CAE) simulation tool.

Several of the tabulated products support both hardware and software development, including StateMate from i-Logix and SES/workbench 2.0 from Scientific & Engineering Software Inc.

The recent integration initiatives are expected to move the CASE industry further toward the promise of full software and hardware development support.

ABOUT THE AUTHOR. Andrew Topper is president of Foresite Systems, a consulting firm in Okemos, Mich. He regularly consults and reports on CASE and software automation. He has a B.S. in computer science from Grand Valley State University, Grand Rapids, Mich. ◆

Logic synthesis

(Continued from p. 33)

clude minimizing scan-chain lengths and area overhead, providing a way of measuring path delay, and eliminating redundancy at the interface between separately synthesized subcircuits.

The primary platforms for logic synthesis tools are PCs and Sun Sparcstations. New platforms becoming more popular are the IBM RS/6000, DECstations, and the Hewlett-Packard PA RISC line.

Since logic synthesis is fairly new, unforeseen breakthroughs can be expected. Already, several research trends indicate what new features can be expected in commercial products in a few years. For example, sequential logic synthesis—in addition to the combinational logic synthesis available in today's tools—will allow more complete optimization. With sequential logic synthesis, for instance, a circuit can be optimized by merging combinational logic on different sides of a register (to balance pipeline stage delays, for instance).

Another new feature will be high-level synthesis. While logic synthesis will help with logic design, it cannot help with key decisions like how many state machines to use, which operations can share logic and registers, when to pipeline, or how many cycles to use for a given operation. Designers have to make these decisions themselves, drawing on their experience. But high-level synthesis will automatically transform a behavioral specification—that is, an algorithm—into a hardware structure at the register-transfer level.

Soon, too, synthesis tools will offer formal design verification. Since any tool—and designer—can err, their results have to be verified. Simulation is used routinely for this, but it is time-consuming for both the computer and the designer, and there is no guarantee that it will catch all possible errors. Formal verification, as part of future synthesis tools, will automatically prove that the specification and the synthesized design are equivalent. Formal verification is almost ready for use on combinational circuits and finite-state machines.

The pioneers of logic synthesis have seen their ideas transformed into commercial tools in a remarkably short time, a testimony to the urgent need for this design aid.

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Douglas S. Reeves [M] is an assistant professor of computer science and engineering at North Carolina State University, Raleigh. He does research on computer architecture and computer-aided design. He has a computer science Ph.D. from Pennsylvania State University, University Park. ◆

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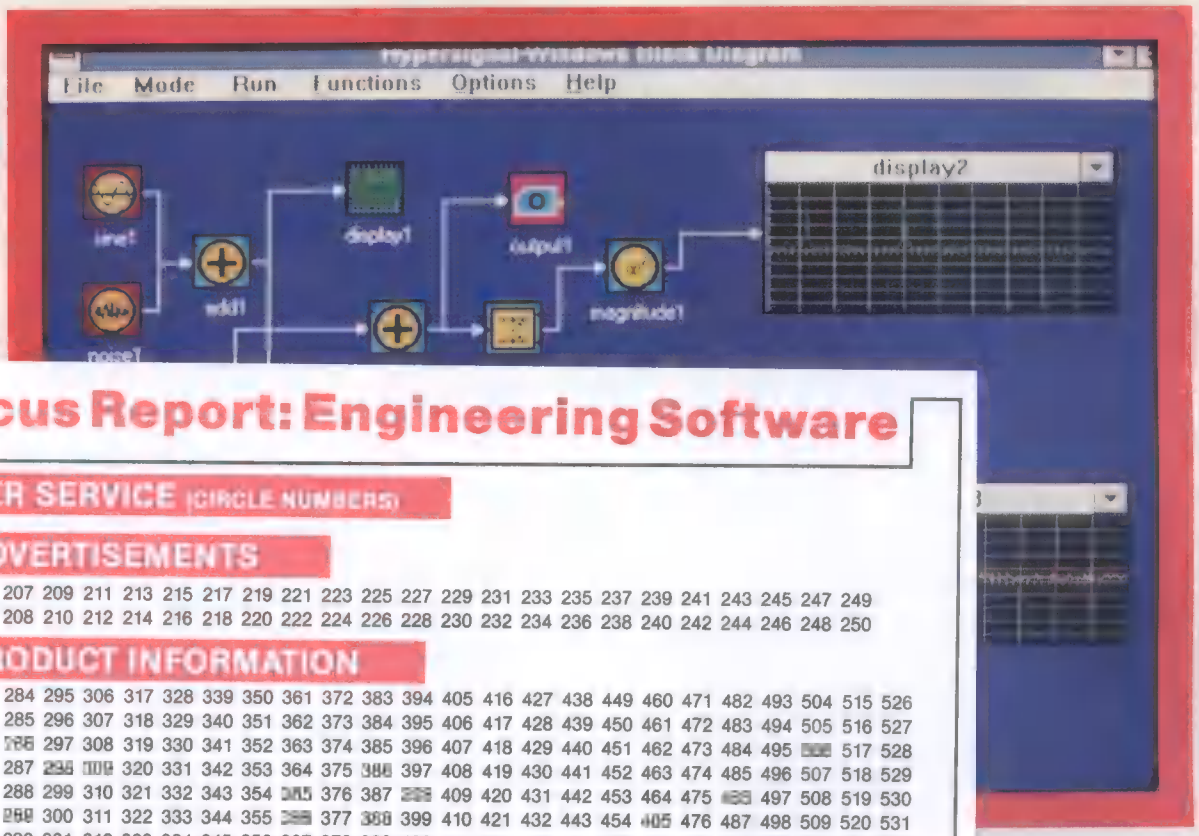

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Software development

(Continued from p. 58)

products are adding support for block diagrams or a hardware description language (HDL) for modeling and designing hardware components. Some products in this category can also generate the IEEE-1076 standard HDL for very high-speed integrated circuits (VHSIC), or VHDL, from specifications. When properly integrated, VHDL code may drive any standard computer-aided engineering (CAE) simulation tool.

Several of the tabulated products support both hardware and software development, including StateMate from i-Logix and SES/workbench 2.0 from Scientific & Engineering Software Inc.

The recent integration initiatives are expected to move the CASE industry further toward the promise of full software and hardware development support.

ABOUT THE AUTHOR. Andrew Topper is president of Foresite Systems, a consulting firm in Okemos, Mich. He regularly consults and reports on CASE and software automation. He has a B.S. in computer science from Grand Valley State University, Grand Rapids, Mich. ◆

Logic synthesis

(Continued from p. 33)

clude minimizing scan-chain lengths and area overhead, providing a way of measuring path delay, and eliminating redundancy at the interface between separately synthesized subcircuits.

The primary platforms for logic synthesis tools are PCs and Sun Sparcstations. New platforms becoming more popular are the IBM RS/6000, DECstations, and the Hewlett-Packard PA RISC line.

Since logic synthesis is fairly new, unforeseen breakthroughs can be expected. Already, several research trends indicate what new features can be expected in

synthesis tools, will automatically prove that the specification and the synthesized design are equivalent. Formal verification is almost ready for use on combinational circuits and finite-state machines.

The pioneers of logic synthesis have seen their ideas transformed into commercial tools in a remarkably short time, a testimony to the urgent need for this design aid.

ABOUT THE AUTHORS. Robert Damiano is manager of the logic synthesis group at the IBM Thomas J. Watson Research Center, Tarrytown, N.Y. He has a Ph.D. in mathematics from the University of Oregon, Eugene.

Douglas S. Reeves [M] is an assistant professor of computer science and engineering at North Carolina State University, Raleigh. He does research on computer architecture and computer-aided design. He has a computer science Ph.D. from Pennsylvania State University, University Park. ◆

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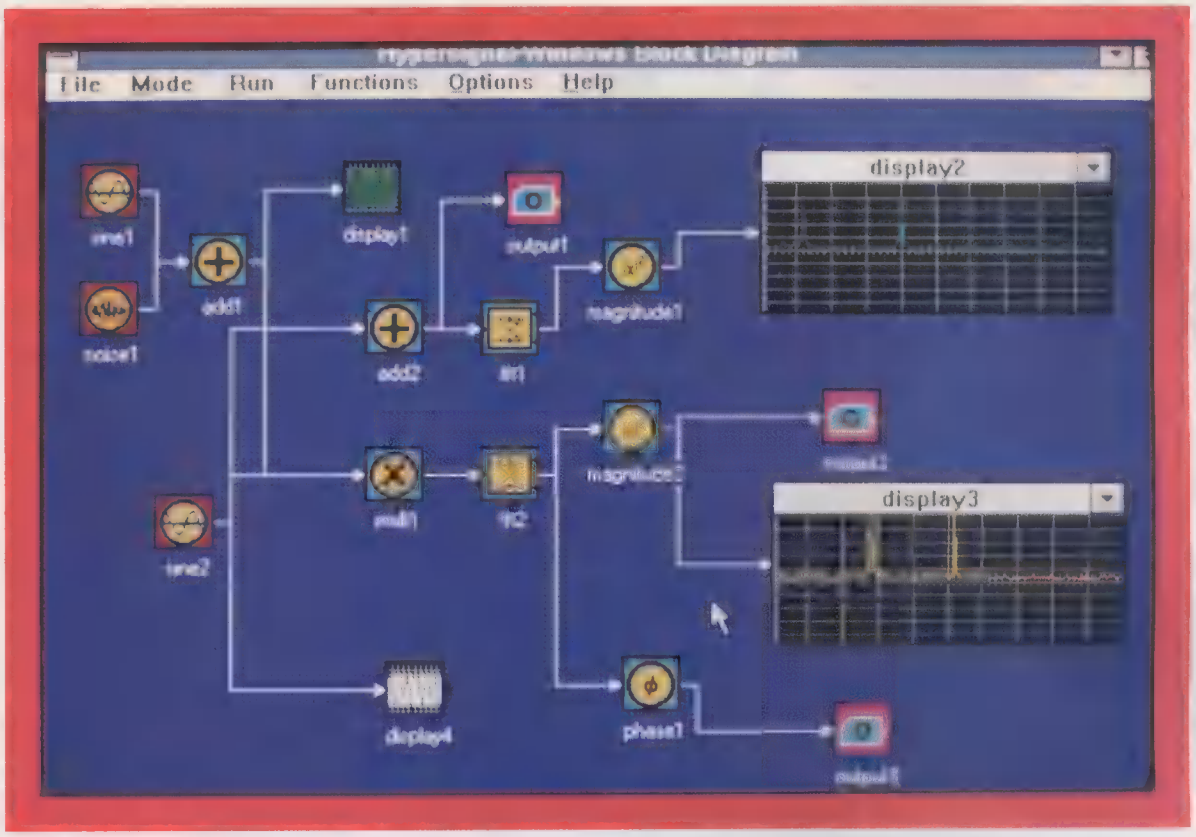

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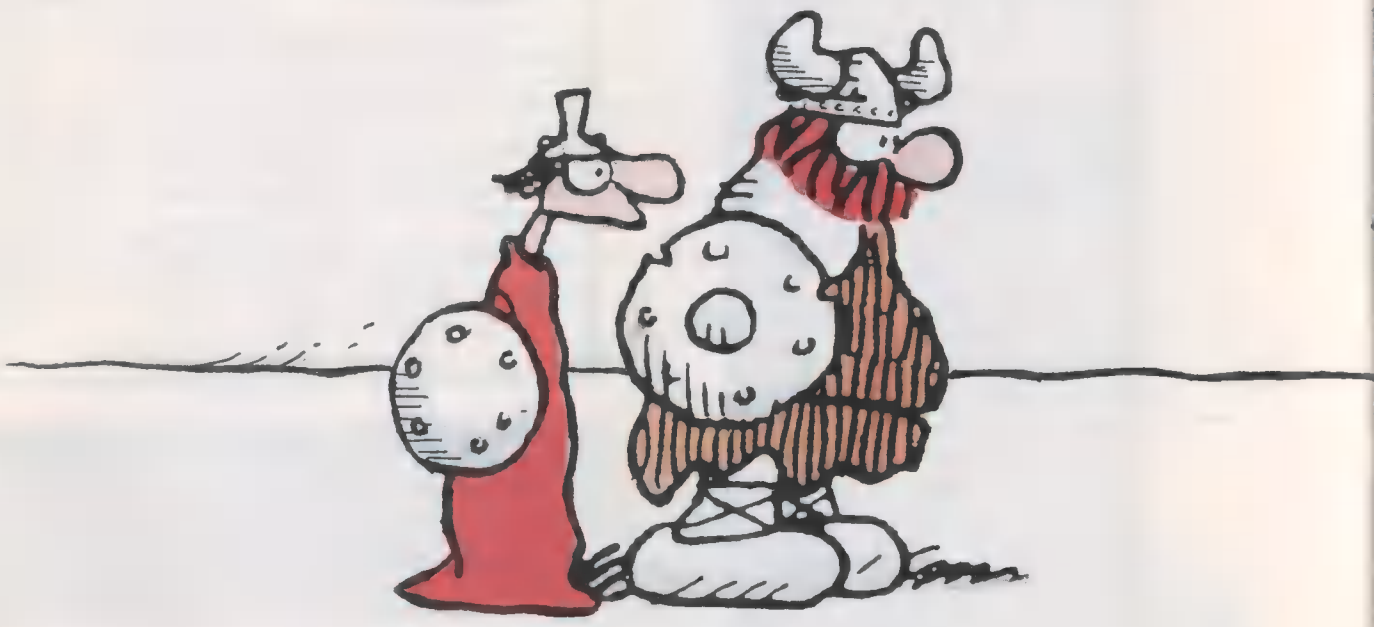

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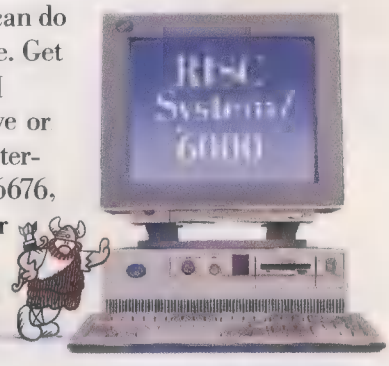

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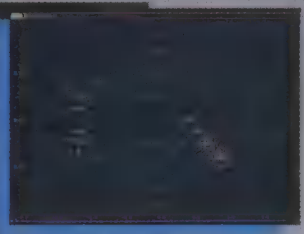

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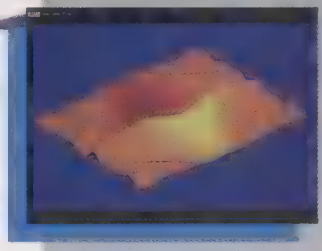

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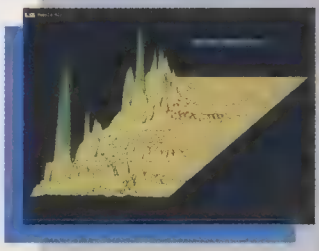

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Software reviews

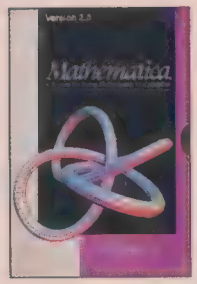
Mathematica update

by Kenneth R. Foster

This is a major upgrade to the well-known mathematical analysis program. Mathematica's chief selling point is an extremely wide range of functions in a package with a consistent user interface. It offers comprehensive symbolic and numerical capabilities, stunning graphics, several levels of programming, and much else. Version 2 adds still more features, and now supports nearly 850 built-in functions. If other programs are the drills and hammers of our profession, Mathematica is a complete shop.

A full review would compare the package's individual functions with those of other programs. My comments focus on its use with MS-DOS systems.

Because Mathematica is a large program, nearly 8 megabytes in size, it can run under MS-DOS only by constantly shifting code to the hard disk in a virtual memory scheme. For reasonable performance this calls for a fast computer with lots of memory (preferably 8 Mbytes or more) and a fast disk. The program ran quickly enough on my system (a 33-MHz Intel 80486-based computer with 8 Mbytes of memory and MS-DOS 5); potential users should check that their own systems are fast enough for the calculations they intend to make. If the memory is improperly configured, Mathematica will run very slowly or not at all.



Mathematica Version 2. *Wolfram Research Inc. Software for numerical, symbolic, and graphical computation. The version reviewed requires an Intel 80386 or 80486 CPU, MS-DOS 3.0 or higher, 640K of main memory, at least 3-Mbyte extended memory, plus disk space of 10-12 Mbytes for the program, plus 16 Mbytes for use by virtual memory; long calculations need more hard disk space. US $695-$1295, depending on math coprocessor support. Versions for many other computers available.*

Compared with versions for other platforms, the MS-DOS version has obvious limitations. Gone is the nice graphical interface of other versions and the highly regarded Notebooks feature. (The vendor has announced a Windows version for release this year, with a graphical user interface and Notebooks.) The program also has obvious loose ends, such as functions listed in the help menu but not implemented. It also has some bugs—it incorrectly evaluates at least one integral, for example.

That said, Mathematica is a wonderful product. One command finds the analytical solution to a differential equation, another numerically solves the same equation, a third creates a phase plot of the results, and a fourth produces output ready for typesetting (in TeX). For the "big picture," a fifth command will display a map of the world. What other program boasts such a range of functions? *Contact: Wolfram Research Inc., 100 Trade Center Dr., Champaign, Ill. 61820-7237; 217-398-0700; or* **circle 104.**

Kenneth R. Foster (F) is an associate professor in the department of bioengineering of the University of Pennsylvania in Philadelphia.

Analyzing dynamic systems

by Raymond H. Kraft

The Xmath tool is designed to aid engineers in developing and analyzing dynamic systems. Consisting basically of the Xmath core and three other modules—for controls, robustness, and optimization—it runs in a workstation environment under X-Windows.

Created by Integrated Systems Inc., the tool is functionally similar to products like Matrix$_X$, Control-C, and Promatlab. Even so, it differs from them in many ways.

The most noticeable difference is its user interface. Relying heavily on the X-Windows environment, the interface uses six major windows, one each for: entering commands and viewing results; obtaining help from detailed explanations and examples; listing defined variables; debugging scripts and functions; obtaining graphical output; and editing individual matrix elements.

Another major area of difference is in data types and operations on various data types. Xmath data types, or objects, belong to one of the following categories: matrices, polynomials, parameter-dependent matrices, dynamic systems, strings, and lists. Parameter-dependent matrices (PDMs), a useful object not available in Xmath's competitors, give the user a straightforward way of describing a matrix as a function of an independent parameter. They are essentially three-dimensional matrices. For example, the frequency or time response of the multi-input, multi-output dynamic system is defined as a PDM. Thus, the user can directly refer to a particular input/output pair without the tiresome task of doing 3-D-to-2-D matrix index conversions.

A useful feature of Xmath is the way it handles operations on various objects. For example, when it multiplies two dynamic systems, it performs a cascade connection.

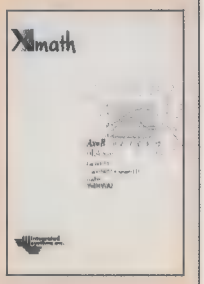
Also, Xmath allows the user to write scripts and define new user functions. These user-defined functions work just like built-

Software reviews

in functions. It is even possible to provide help information on a user-defined function that can be accessed via the help command.

Xmath has a satisfying interface for plotting data. Like the other software tools mentioned, it lets the user plot data from the command line. Unlike other tools, Xmath also allows the user to interactively modify a plot with the mouse.

Xmath. *Integrated Systems Inc. Software for general data analysis, design of control systems and signal processing for Sun workstations, DECstations, and the IBM RS/6000 workstation. Requires 16 Mbytes of RAM. US $2495.*



Like most new products, Xmath has a lot of minor bugs that need to be fixed. Despite this, it is a fairly easy piece of software to learn. Its developer has designed it to be fully internally documented, and the printed documentation is consequently very limited.

All in all, Xmath is already an excellent tool for analyzing dynamic systems; it does, however, need a little more time to mature. *Contact: Integrated Systems Inc., 3260 Jay St., Santa Clara, Calif. 95054; 408-980-1500; or* **circle 105.**

Raymond H. Kraft received a Ph.D. in aeronautical engineering from Stanford University, California, in 1989, and is currently a controls engineer with Boeing Aerospace in Seattle, Wash.

COORDINATOR: Gadi Kaplan

Recent software

ImageScale. Analysis and processing software for full-color, high-resolution images. For DOS version 3.3 and up. Operates within Microsoft Windows. (Included in the National Aeronautics and Space Administration's shuttle mission of Sept. 12, 1991.) US $1995–$2992, depending on which image grabber hardware is used. *Electronic Imagery Inc., 1300 Park of Commerce Blvd., Suite 273, Delray Beach, Fla. 33445; 407-243-7947; fax, 407-243-9531; or* **circle 106.**

RPlot Version 2.00. For plotting of engineering and scientific data. For MS-DOS version 3.0 or higher on IBM PC, AT, PS/2, and compatibles. 256K RAM required. US $149. *RSoft Inc., 345 Riverside Dr., Suite 2G, New York, N.Y. 10025; 212-666-0959; fax, 212-666-3962; or* **circle 107.**

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In order to conform to the Age Discrimination in Employment Act and to discourage age discrimination, IEEE may reject any advertisement containing any of these phrases or similar ones, "recent college grads," "1-4 years maximum experience," "up to 5 years experience," or "10 years maximum experience." IEEE reserves the right to append to any advertisement, without specific notice to the advertiser, "Experience ranges are suggested minimum requirements, not maximums." IEEE assumes that, since advertisers have been notified of this policy in advance, they agree that any experience requirements, whether stated as ranges or otherwise, will be construed by the reader as minimum requirements only. While IEEE does not ban the use of the term "entry level," its use is discouraged since, to some, it connotes an age rather than experience designation. IEEE accepts employment advertising to apprise its members of opportunities. Interested parties should be aware that the political and humanistic values of certain advertisers may differ from their own. IEEE encourages employers to offer salaries that are competitive, but occasionally a salary may be offered that is significantly below currently acceptable levels. In such cases the reader may wish to inquire of the employer whether extenuating circumstances apply.

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All classified advertising copy must be received by the 25th of month, two months preceding date of issue. No telephone orders accepted. For further information contact Theresa Fitzpatrick, 2127057578.

The following listings of interest to IEEE members have been placed by educational, government, and industrial organizations as well as by individuals seeking positions. To respond, apply in writing to the address given or to the box number listed in care of *Spectrum* Magazine, Classified Employment Opportunities Department, 345 E. 47th St., New York, N.Y. 10017.

Academic Positions Open

Endowed Chair (continuation of search). The Department of Electrical and Computer Engineering at Clemson University is seeking nominations and applications for the Holcombe Endowed Chaired Professorship in Electronic Communications Systems. Applicants should have earned doctorates and established national/international reputations in communications disciplines such as classical communications, communications networking, high speed communications, electronics for communication systems, technologies providing communications channels (e.g. microwave/mmwave electronics or electro-optics), or related areas. The successful applicant is expected to join an existing effort at Clemson and help expand and continue its development into one of prominence in both research and instruction. Nominations and applications, including professional vitae, should be submitted to Prof. John Gowdy, Chairman Holcombe Search Committee, Department of Electrical and Computer Engineering, Riggs Hall, Clemson University, Clemson, SC 29634-0915. Selection of applications will begin October 15, 1991 and continue until the chair is filled. Clemson University is an Equal Opportunity/Affirmative Action employer. Clemson University is the land-grant university for South Carolina and located in the state's scenic Piedmont region. The quality of life stems from the outdoor recreation available, the reasonable cost of housing and living expenses, and the thriving metropolitan area of Greenville, approximately thirty miles from campus and ranked by Inc., Magazine one of the twenty fastest growing markets in the country. The Clemson College of Engineering's graduate

program was listed as one of the United States' "up-and-coming" graduate programs in the March 19, 1990 issue of U.S. New and World Report. The ECE Department comprises thirty-six full-time faculty, approximately 700 undergraduate students and 140 graduate students. It offers B.S., M.S. and Ph.D. degrees in both electrical engineering and computer engineering. The Holcombe Chair is fully endowed; in addition Clemson intends to provide support and resources to enable the chair holder to accomplish his/her goals.

Faculty Positions—University of Notre Dame. The Department of Computer Science and Engineering at the University of Notre Dame invites applications for tenure track faculty positions at all ranks. Applicants should have a doctorate in Computer Science, Computer Engineering, Electrical Engineering, or ■ related field. Candidates in all research areas are invited to apply. However, areas of particular interest within the Department are Parallel and Distributed Computing, Parallel Architectures, and VLSI. Applicants should have abilities and interests in teaching at the undergraduate and graduate levels, advising students, and conducting research. Rank and salary are negotiable. Interested persons should forward a complete resume, together with the names, addresses, and telephone numbers of at least three references, to: Dr. Steven C. Bass, Chairman, Department of Computer Science and Engineering, University of Notre Dame, Notre Dame, IN 46556. The University of Notre Dame is an Affirmative Action/Equal Opportunity Employer.

Graduate Assistantships in Optics ■1 CREOL. The Center for Research in Electro-Optics and Lasers (CREOL) at the University of Central Florida is seeking highly qualified applicants for a number of Graduate Assistantships in optics. Stipends range from $11,000 to $15,000 for 12 months. Exceptional students will be considered for assistantship enhancements up to $4,000 through the Litton Foundation and United Technologies Optical Systems. Degrees of MS and Ph.D. in Engineering and Physics are offered at UCF. CREOL has 28 faculty positions devoted to lasers and optical sciences and engineering. The academic program includes basic Electrical Engineering and Physics courses as well as, 23 specialized courses in electro-optics and lasers. Current research activities include: laser propagation, laser/material interaction, nonlinear optics, integrated-optics, infrared systems, optical signal processing, laser development, detector technology, ultrafast phenomena, x-ray sources, and lithography, nonlinear optical spectroscopy, diffractive optics, thin film optics, metal vapor lasers, free electron lasers, optoelectronics, growth of nonlinear and laser host materials, superconductivity, solid state and micro lasers, and others. Applications are invited from students with an excellent academic record and fluent command of the English language. Completed applications are due by February 15, 1992. To receive an application package, write to: CREOL-University of Central Florida, Graduate Affairs Committee, 12424 Research Parkway, Suite 400, Orlando, Florida 32826.

University of California, Santa Barbara, Electrical and Computer Engineering. Applications are invited for at least two tenure-track assistant professor faculty positions, available effective 7/1/92. One position is in the area of optical computing and interconnections, optical communications and networks, or quantum electronics. The other position is in the area of networking and communications. Normally, completion of a doctorate is required at the time of the appointment. Candidates should have an established research reputation or outstanding research potential, the ability to attract external research funding, and a strong commitment to teaching at the undergraduate and graduate levels. Applicants should send their resumes and the names and addresses of at least four professional references to: Faculty Search Committee, Department of Electrical and Computer Engineering, University of California, Santa Santa Barbara, CA 93106-9560. Applications will be received until the positions are filled. Proof of U.S. Citizenship or eligibility for U.S. employment will be required prior to employment (Immigration Reform and Control Act of 1986). UCSB is an Equal Opportunity/Affirmative Action employer.

Arizona State University seeks Scientist/Engineer to manage the staff and operations of the research laboratories of the Center for Solid State Electronic Research. The Center is ■ shared resource research center in the College of Engineering at Arizona State University. Laboratories in the Center include ■ 4000 sq. ft. clean room, semiconductor processing equipment, MBE laboratory, optical characterization and electrical characterization labs, X-ray topography, SEM's, mask making facility, and a computational microelectronics laboratory. Research and teaching opportunities are also available. Requires Ph.D. degree in electrical engineering or physics, with 3 years experience in directly relevant field. Applicant must be directly familiar with semiconductor processing and cleanroom facilities, and have characterization experience. Salary negotiable depending upon experience and qualifications. Application deadline November 15, 1991, or on the 15th monthly until filled. Send resume to Dr. L. Akers, Director, Center for Solid State Electronics Research, Arizona State University, Tempe, AZ 85287-6206. Arizona State University is an equal opportunity, affirmative action employer.

The Department of Electrical and Computer Engineering at the University of the Pacific is accepting applications for a tenure-track position at the Assistant or Associate Professor level. Candidates should have a Ph.D.; also some industrial experience is desirable. Preference will be given to individuals with expertise in the areas of computer engineering and electronics. Undergraduate education is the primary responsibility; curriculum development, advising, MS-level teaching and clinic supervision, and scholarly activity/research are also expected. UOP is ■ private, comprehensive university with a total enrollment of approximately 3800

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Responsible for defining/managing the Deep Submergence Lab's information management and processing group. In collaboration with Scientific and Engineering Staff, will define future data acquisition/processing needs for telepresence technology. Will provide substantial input in designing [redacted] science programs using this technology and in the development [redacted] telecommunications center which links scientists using telepresence technology ashore with technology [redacted] sea.

M.S. in computer science or appropriate field with 5 years related experience. Successful candidate will have demonstrated the technical skill, motivation, independence, creativity necessary [redacted] complete difficult information systems tasks; must [redacted] and willing to go to sea for extended periods; will [redacted] subject [redacted] U.S. security investigation and must meet eligibility requirements for access to classified information.

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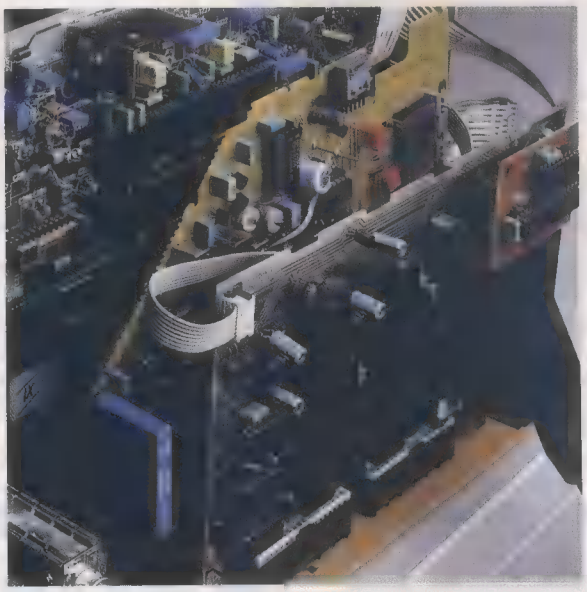
ENGINEERS



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students. Send resume to: Dr. Richard H. Turpin, Electrical and Computer Engineering, University of the Pacific, Stockton, CA 95211. UOP is an Equal Opportunity/Affirmative Action Employer.

Electrical Engineering: Trinity University. The Engineering Science Department invites applications for a tenure track assistant professorship. Qualifications include the Ph.D. or equivalent in Electrical Engineering, a genuine interest in high quality undergraduate teaching and advising, and the ability to develop and maintain research (preferably with undergraduate involvement). Teaching areas include: design; circuits, electronics and microprocessor applications; control systems and robotics; and instrumentation/manufacturing. P.E. or willingness to obtain same is very desirable. Nine full-time faculty teach in this accredited, interdisciplinary program which offers some specialization in chemical, electrical, and mechanical engineering. Women and minorities are urged to apply: TU is an EO/AA employer. Submit resume, visa status and three references by 1 Jan 92 to: Dr. H. William Collins, Dept. of Engineering Science, Trinity University, 715 Stadium Drive, San Antonio, TX 78212, (512) 736-7511.

Clarkson University, Electrical and Computer Engineering. Applications are invited for a tenure-track faculty position as Assistant/Associate/Full Professor in electrical engineering or computer engineering. Responsibilities include undergraduate and graduate teaching and development of a research program. A doctorate is required. Review of applications will begin on November 30th and will continue until the position is filled. The department, consisting of 28 faculty members, offers programs at the B.S., M.S., and Ph.D. levels. Last year 122 EE bachelors, 20 CE bachelors, 15 masters, and 9 doctorate were awarded, and research funding reached more than one million dollars. Principle research areas include distributed and parallel computation, artificial intelligence, image and signal processing, neural networks, robotics and control, communication systems, solid state devices, electromagnetic scattering, power systems, and electromagnetic devices. There are research labs in artificial intelligence and neural computing, VLSI design, robotics, lasers and optics, solid state device fabrication, high voltage engineering, and dielectric breakdown. Clarkson is an independent university specializing in engineering, science and management with an enrollment of 3300 students, including 400 graduate students. Located in northern New York, Clarkson is close to Lake Placid and the Adirondack Mountains. Send applications to Professor Henry Domingos, Chairman, Department of Electrical and Computer Engineering, Clarkson University, Potsdam, New York 13699-5720. Clarkson is an Equal Opportunity/Affirmative Action Employer. Position No. 245.

Faculty Position in Devices-Caltech. The Electrical Engineering program at Caltech invites applications for a tenure-track position as assistant professor. The term of the initial appointment is normally four years, and is contingent on completion of Ph.D. requirements. Exceptionally well qualified applicants may also be considered at the associate or full professor level. Candidates with interests in electronic, magnetics, acoustic, optical, or superconducting devices, and sensors, are encouraged to apply. We are seeking a highly qualified candidate who is committed to a career in research and teaching. Interested applicants should submit a resume with the names and mailing addresses of at least three references to Professor David Rutledge, Department of Electrical Engineering, California institute of Technology, Pasadena, CA 91125. Caltech is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

The Mechanical Engineering Department at Carnegie Mellon University invites applications for tenure-track positions at the Assistant Professor level commencing September 1992 in the following areas: 1. Robotics and Controls (2), 2. Solid Mechanics (1). One of the controls positions is joint with the Robotics Institute at Carnegie Mellon. Applicants must have a Ph.D. in Mechanical Engineering (or closely related field). Duties include teaching undergraduate and graduate courses, and research. Appointments at a higher rank will be considered for qualified applicants having a proven record of grant support. Submit application, complete resume, and names of three references to Professor G.B. Sinclair, Mechanical Engineering Department, Carnegie Mellon University, Schenley Park, Pittsburgh, PA 15213-3890. Closing date for applications is January 31, 1992. Carnegie Mellon University is an affirmative action/equal opportunity employer.

Faculty Positions Available in Electrical Engineering and Computer Science. The University of Michigan Ann Arbor, Michigan. Applications are solicited for faculty positions in electrical engineering and computer science at all ranks. Qualifications include an outstanding academic record, significant involvement in research, a doctorate or equivalent in electrical engineering, computer engineering, or computer science, and a strong commitment to teaching and research. Particular areas of interest include: Solid-state and optoelectronics, integrated optics, millimeter-wave systems and remote sensing, software, distributed systems and networks and theoretical computer science. Please send resume and names of five references to: Professor George I. Haddad, Chair, Department of Electrical Engineering & Computer Science, The University of Michigan, Ann Arbor, MI 48109-2122. An Equal Opportunity/Affirmative Action Employer.

University of Illinois at Chicago. Instructorships and tenure-track faculty positions in electrical engineering and computer science at both the junior and senior level are available. Rank and salary commensurate with qualifications. An earned Doctorate in EE or CS must be completed by date of appointment, but not for the instructorships. Demonstrated teaching and research abilities are highly desirable. For full consideration, please send resume, list of publications, and the names of at least three references by April 30, 1992 to Dr. Wai-Kai Chen, Head, Department of Electrical Engineering and Computer Science (M/C 154), University of Illinois at Chicago, P.O. Box 4348, Chicago, IL 60680. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

RADAR SYSTEMS ENGINEER

Microwave Remote Sensing of the Ocean

The Applied Physics Laboratory of The Johns Hopkins University (APL) continues to pioneer in developing spacecraft and spacecraft radars for monitoring ocean mesoscale activity, climate variations, global ocean circulation, ship routing, deep water oil operations and ocean wave spectra. Our design team is looking for an innovative systems engineer with a PhD in physics or engineering, or equivalent, to work on the edge of advanced remote sensing technologies. A combination of analytical and hands-on hardware expertise with EM/ocean interactions, propagation, antennas, MMIC RF hardware, Electro-Optics, and digital processing is desired. In addition, the ideal candidate will have ten or more years of relevant experience in radar systems design and development, demonstrated abilities to define and articulate concepts and requirements for novel radar systems and a strong desire for a leadership position in radar systems engineering.

APL is a nationally recognized research and development organization located midway between Baltimore, MD and Washington, DC on a 360-acre campus-like setting. We offer a salary commensurate with your qualifications and experience, a comprehensive flexible benefits package, and an attractive retirement program. If you meet our requirements and are interested in this opportunity, please submit a resume and cover letter which details your education, experience and salary history to:

Recruitment Office
Department LER-727
The Johns Hopkins University
APPLIED PHYSICS LABORATORY
Johns Hopkins Road
Laurel, MD 20723

The Johns Hopkins University
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Successful candidates must be experienced in C and UNIX. Positions require at least MSEE or MSCS.

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Test Engineer Power Transformers

Asea Brown Boveri has an opening for a Test Engineer in the testing of Large Power Transformers at its Power T&D Company facility in Muncie, Indiana.

Candidates must have a BSEE with an advanced degree preferred. Two plus years experience in Power Transformer testing to ANSI Standards is desired. Related experience or advanced degree will be considered in lieu of test experience. Must be flexible, innovative, with solid background in transformer technology. Significant customer interaction is required.

An attractive salary, benefits and growth opportunities with a global leader in the electrical utilities industry exists for the right individual. Qualified applicants, please send resume and salary history, for immediate consideration, to:

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The George Washington University
WASHINGTON DC

DEAN

School of Engineering and Applied Science

The George Washington University is reopening the search for the position of Dean, School of Engineering and Applied Science.

The Dean is the chief executive officer of the School and is expected to provide vision and leadership in advancing the interests of the school. The new Dean will be a person who can forge strong cooperative working relationships with faculty and university administrators, and will facilitate the generation of, and support of, programs with key government and business entities.

Candidate should possess the following qualifications:

- An earned doctorate in engineering or science-related field
- A distinguished record as a scholar showing commitment to teaching and research
- Demonstrated administrative ability
- Effective interpersonal and communications skills
- Demonstrated ability in obtaining sponsored research support from government and industry
- Ability and interest in fund-raising activities
- Activity in scholarly and professional organizations
- Commitment to continuing and cooperative education

The School of Engineering and Applied Science is one of eight schools within The George Washington University, located in the Foggy Bottom section of Washington, D.C., close to the White House, Kennedy Center and other prominent national monuments. It consists of the Departments of Civil, Mechanical, and Environmental Engineering; Electrical Engineering and Computer Science; Engineering Management; and Operations Research. Within the purview of these departments, several off-campus graduate teaching and research programs are offered at NASA-Langley, NASA-Goddard, MELPAR, David Taylor R&D Center, among others. The school also runs a major continuing engineering education program.

The George Washington University has established a new graduate campus in Northern Virginia which is expected to permit an exciting synergism of research and education interests between the University and industry. The School of Engineering and Applied Science will play a major role in making this venture a success. The School offers B. S., M. S., Professional, and D.Sc. degrees. The School has 108 full-time faculty, over 600 undergraduate students, and 1100 FTE graduate students. The School's operating budget exceeds $21 million with income from sponsored programs of approximately $8 million.

Application materials should include a cover letter summarizing outstanding qualifications for the position and a current resume. Review of applications and nominations will commence on November 1, 1991 and continue until the position is filled. The intended starting date for the position is July 1, 1992. Salary and benefits are competitive.

Send materials to:

Engineering Dean Search Committee
Attention: Ms. Cleo Graves
Rice Hall, Room 801
The George Washington University
Washington, DC 20052

The George Washington University is an equal opportunity/affirmative action employer.

The Air Force Office of Scientific Research 1992 Summer Research Program Offers Paid Opportunities for Faculty and Graduate Students

The Air Force Office of Scientific Research (AFOSR) is offering research opportunities for 150 faculty and 100 graduate students at its Air Force research laboratories nationwide for 8 to 12 weeks this coming summer. These unique opportunities include a weekly stipend, an expense allowance, and, for faculty, a funded orientation visit as well as a chance to be awarded up to $20,000 for follow-on research. Disciplines sought include:

- **Aeronautical Engineering**
- **Astronautical Engineering**
- **Behavioral Sciences**
- **Chemistry**
- **Civil Engineering**
- **Electrical Engineering**
- **Geophysics/Meteorology**
- **Life Sciences**
- **Materials Science**
- **Mathematics/Computer Science**
- **Mechanical Engineering**
- **Physics**

The program is open to full-time faculty or graduate students of accredited academic institutions. Faculty must be U.S. citizens or permanent residents. Graduate students must be U.S. citizens. **For further information or applications, contact: Research & Development Laboratories, Summer Research Program Office, 5800 Uplander Way, Culver City, CA 90230-6608, or call (800) 677-1363 or (310) 410-1244.** Applications must be received by **January 31, 1992 (faculty)** or **April 1, 1992 (graduate students)**.

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KING FAHD UNIVERSITY OF PETROLEUM & MINERALS DHAHRAN 31261, SAUDI ARABIA

SYSTEMS ENGINEERING DEPARTMENT

PRESENTLY, THE DEPARTMENT OF SYSTEMS ENGINEERING HAS VACANCIES FOR THE ACADEMIC YEAR 1992-93, STARTING SEPTEMBER 1, 1992.

CANDIDATES ARE REQUIRED TO HAVE A PH.D. DEGREE WITH A STRONG COMMITMENT TO RESEARCH AND TEACHING IN:

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ROBOTICS AND AUTOMATION AND
COMPUTER AIDED DESIGN OF CONTROL SYSTEMS

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Interested applicants are requested to send their Curriculum Vitae with supporting documents not later than one month from the date of this publication, to:

DEAN OF FACULTY AND PERSONNEL AFFAIRS
KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
DEPT NO. 9140
DHAHRAN 31261, SAUDI ARABIA

PENNSTATE Erie The Behrend College

DIRECTOR, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

Penn State Erie, The Behrend College, invites applications and nominations for the position of Director of the School of Engineering and Engineering Technology.

Penn State-Behrend is a comprehensive university campus with four-year and graduate programs and with an emphasis on both scholarship and teaching. It is located in suburban Erie, the third largest city in Pennsylvania, and has over 3,000 students. Situated in the hills overlooking Lake Erie, the picturesque campus encompasses over 600 acres of natural wooded beauty. The region offers a wide range of indoor and outdoor activities and events.

The School of Engineering and Engineering Technology, a new academic unit due to growth, includes 30 FTE faculty offering baccalaureate programs in mechanical and electrical engineering; and mechanical, electrical and plastics engineering technology; and associate programs in mechanical and electrical engineering technology. Penn State-Behrend is one of the few colleges nationwide to offer an undergraduate program in plastics engineering technology. The University plans to develop graduate programs in engineering.

Expectations for the Position: The Director of the School is expected to: provide leadership, vision, and communicate clearly with faculty and administrators; lead and assist faculty in developing basic and applied research with attention to external funding and the effective use of undergraduate research assistants; lead and assist faculty in developing undergraduate and graduate programs; promote an atmosphere in which faculty are encouraged to achieve their highest potential so that the best faculty are attracted and retained; promote involvement with the local industrial community and interact with other units of the College; work closely with the School's in-charge faculty in each discipline to develop relationships with engineering and engineering technology faculty at the University's seventeen 2-year campuses; and provide organizational skills to develop and implement the School policies and strategic plans, supervise staff and administer budgets.

Qualifications: Candidates must have an earned Ph. D. in engineering, industrial experience, and adequate credentials for the rank of tenured professor at the time of appointment. Professional registration is preferred. Applicants must have an excellent record of teaching, scholarship, and refereed research with considerable grants activity and effective organizational experience. Applicants should also have a record of service and experience with professional accreditation boards.

Appointment and Application Information: This tenured faculty position carries a standing 12-month appointment to be effective July 1, 1992. Salary is nationally competitive. The search will continue until the position is filled, and dossiers will be reviewed as they are received. Candidates should forward a detailed vita. Please include a letter of application of not more than two pages, commenting on strengths you would bring to the position. **Chair, Engineering Search Committee, c/o Provost's Office, Box IEEE, Penn State Erie, Station Road, Erie, PA 16563-0101.**

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STANFORD UNIVERSITY

PhD PROGRAM IN MANUFACTURING

FOR OUTSTANDING INDIVIDUAL WANTING TO BECOME PROFESSORS

The School of Engineering and the Graduate School of Business seek applicants for a new program designed to prepare outstanding experienced individuals for university faculty appointments in traditional departments where they will focus their teaching and research on manufacturing. This program is coordinated by the Stanford Integrated Manufacturing Association (SIMA) under a grant from the Sloan Foundation.

Candidates must be admitted to the PhD program of a host unit (a department in the School of Engineering or a specific area in the Graduate School of Business) and be nominated for this program by the host unit, which will administer the student's program and award its PhD degree. Each Candidate's academic program will be designed to meet the PhD requirements of the host unit and those of the Manufacturing PhD Program in an integrated manner. The dissertation will be in the area of the host unit on a manufacturing problem.

FINANCIAL SUPPORT:

To enable individuals to make the transition from industrial positions to new academic careers, substantial financial support is available under this program:

- Tuition and fees as required, typically equivalent to 2 years full tuition.
- An annual stipend/assistantship commensurate with other assistantships in the host unit. The range for AY 1992–93 will be approximately $12,000–$18,000.
- A loan, with a maximum sum of the stipend and loan of up to $32,000 per year, forgiven over three years after joining the full-time faculty of a US university.
- Grants for support of the dissertation research, and grants to assist in start-up upon joining a university faculty, are also available.

APPLICANT INFORMATION:

- Apply to a chosen host unit, requesting nomination for the Manufacturing PhD program.
- Notify SIMA of your submission of this application to the host unit, enclosing a statement of purpose making a commitment to seek a faculty position in the US.

Consult the host unit for admissions requirement application deadline, and date for announcement of the host unit's admission decision. Selections for the Manufacturing PhD Program will be announced by SIMA at approximately the same time.

For applications to Engineering: Office of Graduate Admissions, Old Union Building 590, Stanford University, Stanford, CA 94305-3052. **For applications to the Graduate School of Business:** Office of Doctoral Program, Graduate School of Business, Stanford University, Stanford, CA 94305-5015. **For more information:** Stanford Integrated Manufacturing Association, Building 530, Stanford University, Stanford, CA 94305-4028.

Engineering Professionals

Atlas Wireline Services, a leading worldwide supplier of formation and reservoir evaluation services, has the following R & D openings at its west Houston facility:

Electrical Engineers
An MSEE degree with three to five years' experience in one of the following disciplines —

- Electromagnetic Instrumentation (Job code EE01)
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Software Engineers (Job code SE01)
An MSEE/MSCS degree and three to five years of programming or systems experience with UNIX, C, X-Windows, and MOTIF is required. Relational databases, SQL, and Oracle are preferred.

Atlas Wireline Services offers competitive salaries combined with an attractive benefits package and the opportunity to work in a progressive professional environment. For consideration, please send your resume, indicating on the return envelope the job code of the position for which you are applying.

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UNC CHARLOTTE

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DIRECTOR OF APPLIED RESEARCH CENTER

Seeking outstanding candidates for Director of the new 75,000 sq. ft. Applied Research Center. Candidates must be qualified for an appointment as full professor in an appropriate academic department. The Director will report to the Dean of Engineering as Associate Dean for Research. Candidates are expected to have postdoctoral experience in an area related to one or more of the Center's primary areas of research which include: Materials Science, Precision Engineering, Optoelectronics, Microelectronics, Environmental Engineering, Biotechnology including Biomedical Technology, and Computer Integrated Manufacturing. Candidates should have a strong record of research and have demonstrated leadership and management skills to work with faculty in engineering and the sciences to continue the development of this multidisciplinary Applied Research Center. Director must also have excellent communication and public relation skills to represent the Center and the University to external agencies. Review of applications will begin October 15, 1991, and continue until the Director has been selected. To apply please send resume and the names of at least three references to: Prof. S. P. Almeida, ARC Search Committee, College of Engineering, UNC Charlotte, Charlotte, NC 28223. UNC is an EO/AA Employer.

Recent books

(Continued from p. 18M)

Control of Complex Systems: methods and technology. *Drouin, M., et al.*, Plenum Press, New York, 1991, 180 pp., $39.50.

Elements of Engineering Electromagnetics, 3rd edition. *Rao, Nannapneni Narayana*, Prentice-Hall, Englewood Cliffs, N.J., 1991, 636 pp., $56.

Introduction to Expert Systems: the development and implementation of rule-based expert systems. *Ignizio, James P.*, McGraw-Hill, New York, 1991, 405 pp., $41.95.

An Eye for Fractals. *McGuire, Michael*, Addison-Wesley, Redwood City, Calif., 1991, 176 pp., $29.95.

Control of Machines with Friction. *Helouvry-Armstrong, Brian*, Kluwer Academic, Norwell, Mass., 1991, 173 pp., $59.95.

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Hardware Annealing in Analog VLSI Neurocomputing. *Lee, Bang W.*, and *Sheu, Bing J.*, Kluwer Academic, Norwell, Mass., 1991, 234 pp., $59.95.

Error Control Coding: an introduction. *Sweeney, Peter*, Prentice-Hall, Englewood Cliffs, N.J., 1991, 199 pp., $47.20.

Subband Image Coding. *Woods, John W.*, Kluwer Academic, Norwell, Mass., 1991, 355 pp., $85.

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VAX/VMS Internals and Data Structures, Version 5.2. *Goldenberg, Ruth E., et al.*, Digital Press, Bedford, Mass., 1991, 1464 pp., $124.95.

80X86 Architecture & Programming, Vol. 2. *Agarwal, Rakesh K.*, Prentice-Hall, Englewood Cliffs, N.J., 1991, 627 pp., $40.

Lenk's Audio Handbook: operation and troubleshooting. *Lenk, John D.*, McGraw-Hill, New York, 1991, 304 pp., $39.95.

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Advanced SNA Networking: a professional's guide to VTAM/NCP. *Ranade, Jay*, and *Sackett, George C.*, McGraw-Hill, New York, 1991, 398 pp., $44.95.

Handbook of Expert Systems in Manufacturing. *Maus, Rex*, and *Keyes, Jessica*, McGraw-Hill, New York, 1991, 561 pp., $54.95.

(Continued on p. 74J)

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(Continued from p. 74H)

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Microsoft Excel, Version 3. *Microsoft Corp.,* Microsoft Press, La Vergne, Tenn., 1991, 282 pp., $29.95.

Non-Conventional Methods in Geoelectrical Prospecting. *Goldman, Mark M.,* Prentice-Hall, Englewood Cliffs, N.J., 1991, 153 pp., $93.50.

Neurocomputing. *Nielsen-Hecht, Robert,* Addison-Wesley, Reading, Mass., 1989, 433 pp., $47.75.

Modern Control Theory. *Brogan, William L.,* Prentice-Hall, Englewood Cliffs, N.J., 1991, 653 pp., $59.

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Implementation of a General-Purpose Dataflow Multiprocessor. *Papadopoulos, Gregory M.,* MIT Press, Cambridge, Mass., 1991, 165 pp., $27.95.

Semiconductors and Semimetals, Vol. 34. *Willardson, R.K.,* and *Beer, Albert C.,* Academic Press, New York, 1991, 629 pp., $139.

AutoCAD for Electronics: a tutorial. *Tumilty, Thomas,* Prentice-Hall, Englewood Cliffs, N.J., 1991, 267 pp., $56.

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Eco-Logic: logic-based approaches to ecological modelling. *Robertson, David, et al.,* MIT Press, Cambridge, Mass., 1991, 243 pp., $35.

The Road from Los Alamos. *Bethe, Hans A.,* Simon & Schuster, New York, 1991, 286 pp., $12.95.

Hardware Design and Simulation in VAL/VHDL. *Augustin, Larry M., et al.,* Kluwer Academic, Norwell, Mass., 1991, 322 pp., $69.95.

Electronic Communication Systems. *Schweber, William,* Prentice-Hall, Englewood Cliffs, N.J., 1991, 801 pp., $50.

VLSI Design of Neural Networks. Eds. *Ramacher, Ulrich,* and *Ruckert, Ulrich,* Kluwer Academic, Norwell, Mass., 1991, 343 pp., $72.50.

Spice Applications Handboook, Vol. 1. *Meares, Lawrence G.,* and *Hymowitz, Charles E.,* Intusoft, San Pedro, Calif., 1990, 257 pp., $29.95.

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Faults & failures

When speed enforcement didn't work

Shortly after midnight on Aug. 28, a New York City subway train hurtled toward the Union Square–14th St. station of the Lexington Avenue line at four times the allowed speed, a safety device designed to stop runaway trains did indeed function, triggering the train's emergency brakes. But the device did not prevent a fatal crash—the brakes could not reduce the train's estimated 75 kilometer-per-hour speed quickly enough. The train derailed while switching on a curve to the local from the express track, where maintenance work was being done.

The New York City Transit Authority (NYCTA) will not discuss the crash officially, citing legal requirements of ongoing Federal, state, and Transit Authority investigations. But newspaper accounts and unofficial comments from first-hand inspectors give this scenario: the lead car hit a row of steel columns to its left, which sheared off much of the lengthwise rear two-thirds of the car. The second car suffered almost no damage. But the third car struck the columns with such momentum that it wrapped itself around them, and the crumpled front end of the fourth car came to rest wedged into the columns. The rest of the 10-car train was undamaged.

Of the 500 passengers, five died in the wreckage, crushed or dismembered, and over 200 were injured. The motorman, who walked away unharmed, was later indicted for manslaughter; police said that he was drunk.

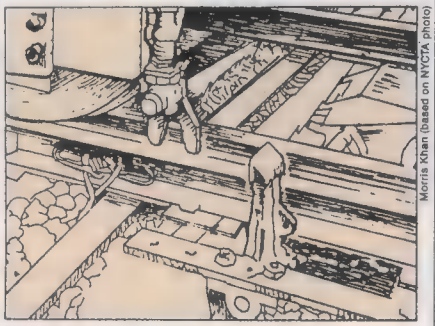
The accident would not have happened if any of three factors had prevailed: if the motorman's condition had been recognized earlier, if the emergency brake had enough distance to decelerate to a safe speed, or if the train's excessive speed had been detected and corrected earlier.

Remarkably, train speed is not directly measured or controlled on New York's subway lines. Instead, a simple timing and trip mechanism is designed to prevent an operator from entering stations or rounding curves at high speed. Called a grade signal, it was originally developed to stop runaway trains descending graded railways.

It works like this: the lead car activates a timer in the track as it passes over the device. Simultaneously, a trip arm located many meters ahead rises at the side of the track. After a preset time has elapsed, the timer releases the arm, and it falls to a horizontal position. The train can pass freely if it is traveling at or below the allowed speed. If it is speeding, however, it will reach the trip arm before the arm has fallen. The trip arm will then bump a trip cock on the lead car's undercarriage [see figure]. This engages the train's emergency brake, and the train will grind to a halt.

This is a go/no-go system, according to an NYCTA engineer; it enforces speed limits but does not regulate speed. An operator whose train trips the mechanism must dismount, reset the trip mechanism on the track, and then reset the emergency brake on the train before continuing.

On a curved section of track, the speed limit is far less than on a straightaway, and the elapsed time is proportionately shorter. At Union Square, trains are expected to slow to 17 km/h or less before entering the curve that leads to the local tracks.



Morris Khan (based on NYCTA photo)

Unfortunately for the passengers aboard the subway train that night, the trip arm is positioned only 10.7 meters ahead of the 14th St. curve. That the arm engaged the trip cock is clear from fresh scrapes on the parts. But, according to one calculation, if the brakes had exerted their maximum deceleration, the 75-km/h train as it entered the curve would have had a speed of 68 km/h—a speed almost guaranteeing derailment.

Investigators from the National Transportation Safety Board measured the effect of emergency deceleration a few days after the accident. Three times, they drove a train identical to that involved in the crash over a safety trip. Each time, the train, initially moving at its top speed of 83 km/h, took much more than 10.7 meters to slow down.

A week after the accident, the NYCTA announced that it would now require that trains come to a full stop before switching to the local track at Union Square. The motorman is expected to contact the control center by radio for permission to proceed. Thomas Prendergast, senior vice president for rapid operations, acknowledged that the authority can no longer rely on human operators and must take steps to reduce that reliance.

Among those steps, NYCTA engineers will identify all dangerous curves and redesign the safety signaling at those places. In essence, the trip arm will be moved farther away from the curve to give a speeding train more room to slow down.

Next year, the authority plans to install speedometers in the train cabs so that operators will at last know their speed. They have driven New York subway trains for years simply by setting the speed control to one of three levels: slow (nominally 8.3 km/h), medium (33.3 km/h), or fast (up to 83.3 km/h), with no feedback about the true velocity.

Also in 1992, transit authority engineers will evaluate the possible use of automatic speed controllers—microprocessor-based systems that protect a train from equipment failure or an operator's disregard for the local speed limit. The controllers compare actual train speed with wayside speed commands. If the train is going too fast, they cut off motor power and apply the brakes until it comes into line.

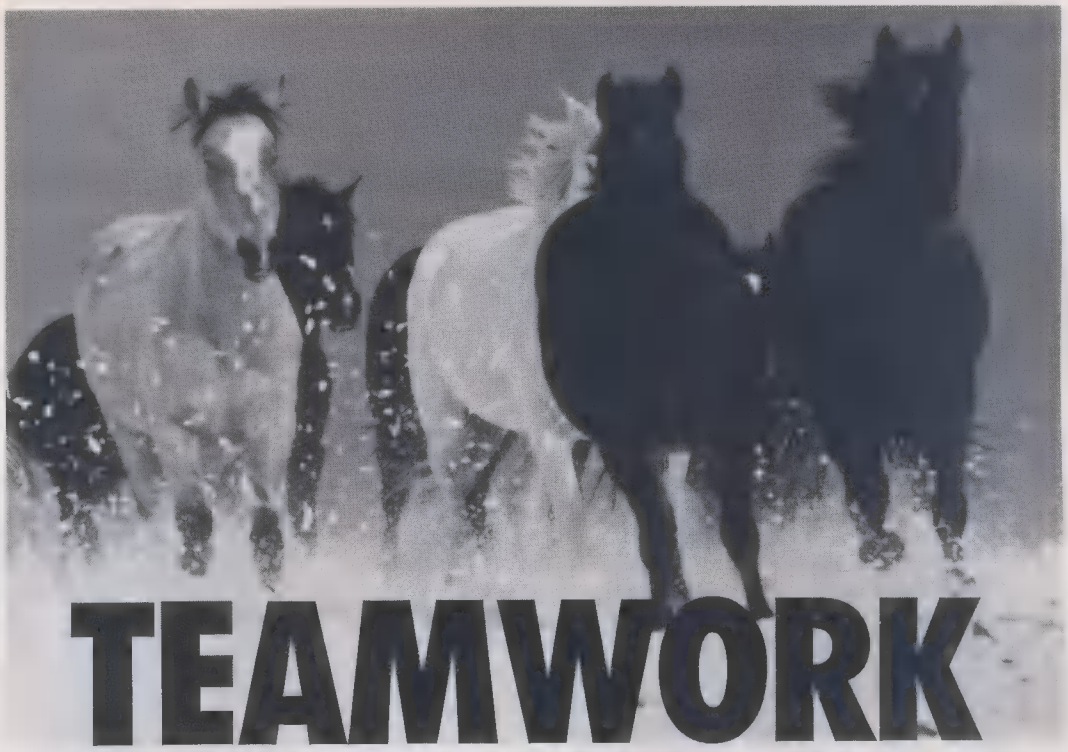
Newer transit systems than New York's Lexington Avenue line (opened in 1904) naturally take advantage of this advanced safety technology—systems like those in Washington, D.C. (opened in 1976), Atlanta, Ga. (1979), and Vancouver, B.C. (1986). The Washington Metro's trains carry small receivers to pick up audio-frequency electromagnetic radiation from the tracks; the signals contain local speed commands based on the distance to the next train ahead and track curvature. The commands are processed to regulate train speed.

Another innovation being considered in New York is equipping each train with blackboxes—like those on commercial airliners—that would keep a record of speed, acceleration, and voice communication between train and control center.

NYCTA has earmarked US $700 million in its next capital spending plan to upgrade signals, but in the aftermath of the accident, higher spending is likely, the authority says.

The authority has also instituted personnel policies designed to reduce the chance of alcohol or drug-related accidents. Train operators will be subject to random drug testing, and personnel records will be reviewed for performance patterns (such as frequent absence or lateness, or recurring disciplinary actions) that may indicate problems. Now maintained manually, the records will be computerized and potential problems will be flagged automatically.

COORDINATOR: George F. Watson
CONSULTANTS: John Devaney, Hi-Rel Laboratories Inc.; Robert Thomas, Rome Laboratory



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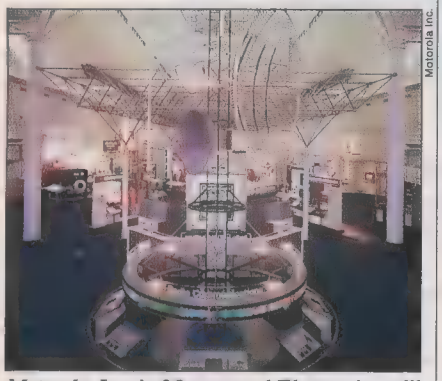
"Binary Bingo" and a tabletop robotics factory are two of the interactive computer exhibits housed in the new 7000-square-meter Motorola Museum of Electronics in Schaumburg, Ill., near Chicago. Drawing on Motorola's history and product lines dating back to 1928, the museum has mounted displays that highlight semiconductors, communications, computers, and high-technology manufacturing techniques. Interactive multimedia workstations are also used to explain basic scientific concepts.



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The museum is open Monday through Friday from 9 a.m. to 4:30 p.m. *Contact: Conference Planning, Motorola Museum of Electronics, 1297 E. Algonquin Rd., Schaumburg, Ill. 60196, weekdays 8 a.m. to 5 p.m., for individual or group visits by appointment at 708-576-8620, and for information about educational programs, 708-576-7813.*

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The password, please

Weak, easy-to-guess passwords have enabled computer hackers to break into supposedly impenetrable computer access-control systems in universities, corporations, and military establishments as well.

A password-screening software package for the Novell NetWare network operating system, Password Coach, trains users to select strong passwords—and that means not picking proper names, geographic locations, or any word that is in the dictionary or derived from the user's personal identification. The system subjects passwords to 39 strength tests, rejecting the weak passwords and allowing the user to continue choosing until a strong password is selected. If the user is unable to construct a strong password, the program generates one.

But the software is totally user-transparent if a strong password is chosen to begin with. Strong passwords must be easy to remember. Some examples are Charles123; Spectrumengineergood (actually a pass phrase); or the first letter of each word of a favorite line of poetry.

Password Coach even comes with an English dictionary of more than 140 000 weak passwords. Dictionaries in 15 other languages are also available.

Price of the software starts at US $795 for up to 10 users. Turnkey interfaces for IBM AS/400 and DEC VAX/VMS are available, too, and ANSI standard C language source code can be licensed. *Contact: Charles Wood, Baseline Software, Box 1219, Sausalito, Calif. 94966-1912; 800-829-8855 or 415-332-7763, or* **circle 101.**

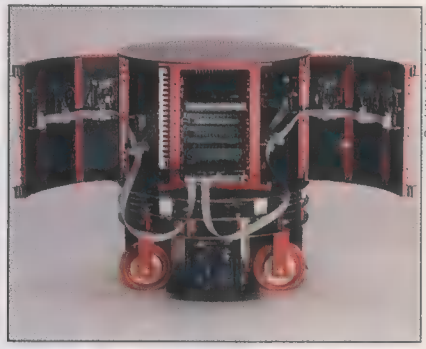
ROBOTICS

A base for your mobile robot

By relying on an off-the-shelf "body" containing a servo-controlled three-wheel drive, and batteries, researchers working with mobile robots can bypass most of the ordinary chores with Real World Interface Inc.'s B12 Mobile Robot Base. The product has been rolling around for about two years, supporting anything weighing up to 20 kg, including mechanical arms and fingers, sensors, and information-processing systems. Now the company has made the assembling of robot systems even easier by introducing a 20-cm-high development enclosure that fits atop the 17-cm-diameter base.

This 12-sided package with swing-open doors contains a card cage, a power supply, a backplane with slots for eight printed-circuit boards to provide on-board computer control and sensor processing, and sites for up to 48 sensors. (A taller enclosure handles up to 60 sensors and 12 pc boards.) The backplane accepts plug-ins with the Eurocard bus format.

The 11.4-kg base, which extends 17 cm above its three wheels, comes in blue, red, black, or silver and relies on a simple mnemonic control language along with an RS-232C serial port. Options include a 432-watthour silver zinc battery pack (instead of the standard 144-Wh lead acid pack), radio- or manually-controlled joysticks (the latter with a cable), and a system to drive up to 60 sonar transducers. Price of the B12 base is US $6500. The development enclosures



Real World Interface Inc.

Making life easier for robot researchers, a development enclosure, shown with its panels opened, sits atop a standard mobile robot base.

start at $2500. *Contact: Grinnell More, Real World Interface Inc., Box 270, Main St., Dublin, N.H. 03444; 603-563-8871; or* **circle 102.**

INFORMATION

Publications from Japan

Like to see a Japanese buyer's guide to electronic components sold in Japan? Interested in the structure of the electronics industry there as seen by the Government's Ministry of International Trade and Industry (MITI)?

Japanese Government ministries translate a number of their publications into English. A list of what is available, including directories, abstracts, forecasts, annual reports, and handbooks, is in the appropriately titled catalog "Japanese Publications in English." Reports on technology, electronics, business, trade, and telecommunications from MITI are also included. Some volumes are in bilingual editions.

The 36-page catalog and an order form are distributed by Overseas Courier Service America Inc. *Contact: Order Department, OCS America Inc., Room 1186, National Press Building, 14th and F Streets, N.W., Washington, D.C. 20045; 202-347-3252; fax, 202-639-8673; or* **circle 103.**

COORDINATOR: Dana Norvila
CONSULTANT: Paul A.T. Wolfgang, Boeing Helicopters

CLASSIFIED EMPLOYMENT OPPORTUNITIES

Engineer Research. Manage facilities and oversee routine operations of Neural Systems Lab. Supervise hardware/software installation and maintenance of Hewlett-Packard workstations. Applications and Kernel-level programming on real-time Unix systems. Manage software development projects in concurrent real-time processing and GPIB protocol device interfacing. Requirements: M.S. in Computer Science or Electrical Engr. with communications emphasis; extensive programming experience in X windows, structured C, Unix, Fortran, LISP; experience in HP system management, user interface design, parallel processing; good communication skills. $36,000 per year. Mail resume, three letters of recommendation, and copy of ad by December 1, 1991 to MD DEED, 1100 N. Eutaw St., Room 212, Baltimore, MD 21201. Job order No. 9048544. Job location: College Park, MD. Proof of legal right to work in US required.

Electrical Engineering Faculty Position: The Pennsylvania State University at Erie, The Behrend College. Applications are invited for a tenure-track faculty position at the Assistant Professor level to teach baccalaureate engineering courses starting Fall Semester 1992. Ph.D. degree in Electrical Engineering or closely related field required; preference will be given to individuals with previous teaching experience and interests in communications, signal processing, and VLSI. Applicants should have an interest in undergraduate teaching, the ability to develop a research program at Penn State-Behrend, and the desire to work with faculty and administration on further development of a new engineering program. Penn State-Behrend is a 4-year, primarily undergraduate institution within the 22-campus Penn State system, and is one of only three Penn State campuses where a student can complete baccalaureate programs. Application deadline is January 1, 1992 or until position is filled. Send complete resume, official transcripts and the names of three references to Dr. A.H. Pulsifer, Head, Division of Science, Engineering & Technology, Department 5-EE, The Pennsylvania State University at Erie, Erie, PA 16563-0203. An Affirmative Action/Equal Opportunity Employer. Women and Minorities Encouraged to Apply.

The Department of Electrical Engineering at the University of California, Los Angeles is involved in a major expansion of its instructional and research facilities in a new engineering building. In addition, an expansion is planned in tenure track faculty positions. Applications are being accepted in the following areas of expertise: Optoelectronics, Optical Signal Processing, Microwave and Millimeter Wave Electronics, Electromagnetics, Analog and Digital Integrated Circuits, Digital Signal Processing, Image Processing, and Communication Systems. Applicants should have a Ph.D. and an outstanding research record in their expertise. Application letters should be mailed to Professor Nicolaos G. Alexopoulos, Chairman, Electrical Engineering Department, UCLA, 58-121 Engr. IV, 405 Hilgard Ave., Los Angeles, CA 90024-1594. UCLA is an Equal Opportunity Affirmative Action Employer.

Electrical and Computer Engineering, Faculty Positions—Penn State. Applications are invited for several tenure-track faculty positions in the Department of Electrical and Computer Engineering at The Pennsylvania State University. Candidates should have a Ph.D. in Electrical/Computer Engineering or a related discipline, ability to establish a strong research program, and a desire to teach at both the undergraduate and graduate levels. Although candidates in all areas will be considered, the following areas will receive priority consideration: computer engineering (especially software), electromagnetics, space science, electro-optics, electronic materials and power systems. The Department of Electrical and Computer Engineering at Penn State currently has over 50 faculty, 800 junior and senior level students, and 280 graduate students. Funded research is being conducted in many areas, including: Electromagnetics, Electro-optics; Signal Processing; Computer Hardware, Software, and Applications: Power; Electronic Materials; Communications; Control and Robotics. Please send resumes and cover letters, with names, addresses and phone numbers of at least three references to: Personnel Committee, Department of Electrical and Computer Engineering, Box IEEE, 129 EE East, The Pennsylvania State University, University Park, PA 16802. Applications received by January 31, 1992 will be assured of consideration; however, applications will be considered until the positions are filled. An Affirmative Action/Equal Opportunity Employer. Women and Minorities Encouraged to Apply.

Faculty Position, Cleveland State University, Department of Electrical Engineering. Seeking applicants for a tenure-track faculty position in Electrical Engineering. Appointment will be at the Assistant or Associate Professor level with a competitive salary and rank commensurate with qualifications. Qualifications include a Ph.D. degree, the abilities to teach in B.S., M.S. and Doctoral-level programs and to engage in a vigorous research program. A specialty in the area of communications is required. Primary departmental interests in communications includes information theory, coding, modulation and equalization. Knowledge of satellite communication systems and/or practical experience is desirable but not required. Faculty members in the department have the possibility of obtaining research support locally through NASA Lewis Research Center. Deadline: When position is filled, with ongoing screening of applications. Starting Date: September 14, 1992. Send resume and list of three references to: Dr. James H. Burghart, Chairman, Electrical Engineering Dept., Cleveland State University, E. 24th & Euclid Ave., Cleveland, OH 44115. Equal Opportunity Employer, m/f/h.

Assistant Research Scientist, 40 hours/week, 8 a.m.-5 p.m. Salary: $37,000/year. Duties include: Research on the design optimization, fabrication, and characterization of ultra-high-frequency transistors and monolithic integrated circuits using novel compound semiconductor materials such as InGaAs and advanced device concepts such as strained high-electron-mobility transistors. Development of advanced fabrication techniques such as double-recess mushroom gate, surface passivation, InP via holes, implant isolation and submicron electron-beam writing system to achieve state-of-the-art transistors and monolithic integrated circuits performance. Educational requirements: Applicants must have a Ph.D. in electrical engineering and one year related experience as a graduate assistant. Other special requirements include: The experience to be in design optimization, fabrication and characterization of ultra-high-speed devices and microwave monolithic integrated circuits (MMICs) using submicron electron-beam writing system. Five publications and/or conference presentations, each on high-electron-mobility transistors and MMICs. One graduate course each in solid-state physics, semiconductor devices, MMICs design and characterization, and microelectronics processing. Employer paid ad. Send resumes to 7310 Woodward Avenue, Room 415, Detroit, Michigan 48202. Reference No. 63491.

Faculty Opening in Biomedical Informatics at Vanderbilt University. Applications are invited for a tenure-track position at the assistant professor level at Vanderbilt University. Exceptionally qualified candidates at other levels of experience will be considered. The position will include a primary appointment in the Department of Biomedical Engineering and a joint appointment in the newly organized Center for Biomedical Informatics at Vanderbilt University School of Medicine. Applicants should hold the Ph.D. or equivalent degree in biomedical engineering, computer science, medical informatics or a related field. The successful candidate will be expected to teach in the undergraduate and graduate programs of the Department of Biomedical Engineering, engage in research in the general area of informatics and computing as applied to biomedical and clinical sciences and participate in the other academic activities of the Center for Biomedical Informatics. Vanderbilt University is an equal opportunity employer. Women and members of minority groups are urged to apply. Applicants should provide a curriculum vitae and the names of three references to Dr. William Stead, Chairman, Medical Informatics Search Committee, Ste. 2000, Village at Vanderbilt, 1500 21st Avenue S., Nashville, TN 37212.

University of Miami, Department of Electrical and Computer Engineering invites applications for tenure-track faculty positions in computer engineering at the Assistant/Associate Professor level in the Spring and Fall semesters, 1992. Preferred areas of interests are artificial intelligence, software engineering and database systems. Qualifications include a Ph.D. degree in computer science or computer engineering and the ability of initiating research projects, attracting external funding, and teaching undergraduate and graduate courses. Salary will be commensurate with rank and experience. The University is located in Coral Gables, a suburb of Miami, Florida. Applications should be sent with the names of three references to: Dr Tzay Y. Young, Chairman, Dept. of Electrical and Computer Engineering, Univeristy of Miami, P.O. Box 248294, Coral Gables, Florida 33124. The University of Miami is an equal opportunity/affirmative action employer.

Concordia University Department of Computer Science. We are looking for new faculty members with either strong research records or excellent research potential to fill two tenure track positions in the Assistant or Associate Professor rank. Applicants must have an interest and ability to teach effectively at both the undergraduate and graduate levels. Selected candidates will be expected to carry out independent research and other academic duties associated with our bachelor's, master's and Ph.D. programs. To fit our needs, priorities will be given to the following areas: software engineering, programming languages, expert systems and combinatorial computing. However, truly exceptional candidates in all computer science areas are encouraged to apply. The university is located in Montreal which is well known for its cultural diversity and beauty. The department houses approximately 600 undergraduates, 90 Masters and 30 Ph.D. students. While the undergraduate program emphasizes both fundamental and practical skills, our graduate research concentrates in artificial intelligence, combinatorics, computer algebra, databases, distributed computing, large-scale scientific computing, pattern recognition, programming languages, software engineering and VLSI architecture. There are twenty six full time faculty positions supporting these activities. The department has established CENPARMI (Centre for Pattern Recognition and Machine Intelligence) with specialization in pattern recognition and related expert systems research. The research groups in mathematical computing and VLSI architectures are also members of two inter-university research centres: CICMA (Centre Interuniversitaire en Calcul Mathematiques Algebrique) and GRIAO (Groupe de Recherche Interuniversitaire en Architecture des Ordinateurs de Haute Performance et VLSI). In particular, CICMA promotes research in algebraic computing, combinatorics and computational group theory. The department also intends to strengthen its activities in software systems. To promote the development of new faculty members, the university has a program to provide seed grants for their research in the first three years. Concordia is committed to Employment Equity and encourages applications from women, aboriginal peoples, visible minorities and disabled persons. All things being equal, women candidates shall be given priority. Interested applicants should send a resume and the names of at least three references to: Chair, Department Personnel Committee, Department of Computer Science, Concordia University, 1455 de Maisonneuve West, Montreal, Quebec H3G 1M8, Canada, Fax: (514)848-2830. email: hfli@sunlite.concordia.ca. In accordance with Canadian immigration requirements, priority shall be given to Canadian citizens and permanent residents of Canada.

Joliet Junior College, located 40 miles southwest of Chicago, is seeking applicants for the following position: Electronics Engineering Technology Instructor: Bachelors degree in Electronic Engineering, Electronic Engineering

Technology or related field required. Masters degree preferred. Consideration may be given for combinations of education and related work experience. Must be able to teach courses in many areas of electronics including analog, circuit analysis and linear devices. Five years work experience and/or teaching experience in the electronics field preferred. Application deadline November 15, 1991. Applications and inquiries should be directed to: Michele A. Kazmerski, Manager of Personnel Services, Joliet Junior College, 1216 Houbolt Avenue, Joliet, IL 60436. An Equal Opportunity Employer.

Dean College of Engineering and Applied Sciences, Arizona State University. Arizona State University invites nominations and applications for the position of Dean of the College of Engineering and Applied Sciences. The University: Arizona State University is a major research university comprised of 13 colleges. Over 10,000 of its more than 42,000 students pursue graduate studies. ASU is a multicampus university. The main campus is in the heart of the metropolitan Phoenix in the city of Tempe. Phoenix is a cosmopolitan, culturally diverse area of approximately 2 million people. The College: The College has 11 academic departments and schools and 8 research centers in the School of Engineering, the School of Construction and Technology, and the School of Agribusiness and Environmental Resources. Enrollment in the College includes 4,200 undergraduate baccalaureate students and 2,100 graduate students with 240 tenured or tenured-track faculty members. The research awards received in 1990-91 totaled approximately $12 million. The College of Engineering and Applied Sciences has been recognized for its innovative Engineering Excellence Program, a three-way partnership between state government, industry, and the university. As of 1991, more than $175 million has been invested in achieving this goal. For the second year in a row the College was included by U.S. News and World Report as one of the top two up and coming colleges of engineering in the United States. Duties and Responsibilities: As the chief academic and administrative officer of the College, the Dean reports directly to the Senior Vice President for Academic Affairs and Provost. the Dean provides leadership in ensuring academic excellence in all curricula and programs, and support to the faculty for achieving and maintaining quality teaching, research, and service. The Dean is responsible for developing strong external support, including support among alumni and industry leaders. Qualifications: Candidates for the position must meet the requirements for appointment at the rank of professor in one of the departments within the College. The requirements include an earned doctorate degree, a significant record of scholarly and research accomplishments, demonstrated effectiveness in undergraduate and graduate teaching, and evidence of quality service. Candidates must have appropriate administrative experience through which they have developed strong academic leadership, communication and interpersonal skills, and a demonstrated ability to develop external support, including financial resources. A successful record of promoting cultural diversity is essential. Nomination and Applications: Send nominations and applications to: Larry E. Penley, Chair, College of Engineering Dean Search, c/o Officer of the Senior Vice President and Provost, Arizona State University, Tempe, AZ 85287-2803. Candidates should supply curriculum vitae, a letter of interest, and names, addresses and phone numbers of at least 3 references. The search committee will begin to review applications on December 1, 1991. Applications received after that date will be reviewed on a biweekly cycle, as necessary, until the position is filled. Preferred starting date is July 1, 1992, but the date is negotiable. Salary is competitive. Arizona State University is an Equal Opportunity, Affirmative Action Employer.

Director, Institute for Biomedical Computing. The Washington University Institute is an academic unit attached to both the School of Medicine and the School of Engineering and Applied Science. It is composed of several laboratories and groups (Biomedical Computer Laboratory, Center for Molecular Design, Medical Informatics Group, and Sensory Biophysics Laboratory) which carry out broad interdisciplinary research programs in biomedical computing, quantitative imaging, bioengineering, biophysics, medical informatics, and computational chemistry. Close collaborative interactions are with faculty of schools of medicine and engineering, research professionals, and students, both at Washington University and elsewhere. Graduate training and ties with Biomedical Engineering are especially important. The Director works with the leaders of the Institute components and with a Governing Board (prominent faculty and administrators from both schools) to maintain a stimulating environment for the Institute's research programs. In addition to carrying out a personal research agenda, the Institute Director is responsible for coordinating existing research programs, developing new research directions, overseeing personnel and budget matters, and coordinating Institute programs with other research and teaching programs at both schools. Qualifications include an M.D. and/or Ph.D. in bioscience or a Ph.D. in an engineering discipline, at least five years of significant research and administrative experience, demonstrated leadership abilities, and excellence in intellectual and academic performance. Candidates should submit a resume, a publication list, and at least three reference to Dr. James McKelvey, Department of Chemical Engineering, Campus Box 1198, Washington University, One Brookings Drive, St. Louis, MO 63130. Washington University is an equal opportunity, affirmative action employer.

Research Associate. Applications are invited for a research associate/post-doctoral position in the of epitaxial growth of compound thin films (GaAs & InP based technologies) using a metal-organic chemical vapor deposition (MOCVD/MOVPE) system. The person will work with an existing group of faculty to design and implement growth processes for quantum well and superlattice structures for microwave, electronic, and photonic devices. He/she will be responsible for the operation of the recently acquired state-of-the-art MOCVD machine and associated materials characterization equipment. Applicants should have a Ph.D. in electrical engineering, or physics, or material science, or chemistry with experimental orientation and hands-on experience. Preference will be given to applicants with actual MOCVD and/or MBE growth experience. Experience with materials characterization techniques and equipment such as x-ray, ESCA, TEM, PL, SIMS, and other microelectronics fabrication is highly desirable. Send resume to Prof. Vik J. Kapoor, Department Head, Department of Electrical and Computer Engineering, University of Cincinnati, Cincinnati, Ohio 45221-0030. The university is an affirmative action, equal opportunity employer.

Endowed Chair in Rehabilitation Engineering. The Department of Biomedical Engineering, University of Tennessee, Memphis announces the establishment of the J.R. Hyde Chair of Excellence in Rehabilitation Engineering. This endowed chair will support a distinguished professor with a national reputation in research, education, and service in rehabilitation engineering (e.g. biomechanics, biomaterials, or prosthetics). The University of Tennessee, Memphis has established 26 endowed professorships and Centers of Excellence in Molecular Resources, Neurobiology, and Pediatric Pharmacokinetics and Therapeutics. The University comprises Colleges of Medicine, Dentistry, Nursing, Pharmacy, Graduate Health Sciences and Allied Health Sciences. Candidates should have a Ph.D. in engineering, have several years experience at the Associate Professor level or higher, and presently direct a major and continuing federally supported research program. The deadline for submitting applications for review is Dec. 31, 1991; however, applications will be accepted until a suitable candidate has been identified. Applicants should send a curriculum vitae and the names, addresses, and telephone numbers of five references to: Professor Herbert D. Zeman, Chairman of the Search Committee, Department of Biomedical Engineering, University of Tennessee, 894 Union, Nash Building-Suite 250, Memphis, TN 38163. Minority candidates and women are especially encouraged to apply. The University of Tennessee is an EEO/AA/Title IX/Section 504/ADA employer. Rev. 2 (4/91).

Research Associate Biomedical Engineering, University of Tennessee, Memphis. The Department of Biomedical Engineering, University of Tennessee, Memphis is seeking to fill a Research Associate position in its Medical Imaging Research Group. The position is funded for two years by a research grant from the National Science Foundation aimed at studying the feasibility of performing intravenous coronary angiography using K-emission X-rays. Experiments will be performed at Brookhaven National Laboratory. Applicants must possess a doctoral degree in biomedical or electrical engineering, medical physics, or related fields, and should have experience in experimental digital imaging research. Experience with CCD TV camera systems or high power electron accelerators is desirable. Applications will be received until the position is filled; however, review of applications will begin on December 1, 1991. The BME Department currently has nine core and joint faculty, three administrative staff, a Bioinstrumentation Division consisting of eighteen staff (13 electronic technicians and machinists, and five clerical and supervisory staff) and a recently-initiated M.S. and Ph.D. graduate program. In the Fall, 1991, the department is scheduled to move into newly-renovated space in Baptist Memorial Hospital, the nation's largest private hospital. Applicants should submit a curriculum vitae, list of publications, date of availability for employment, and the names of three references to: Professor Herbert D. Zeman, Department of Biomedical Engineering, Nash Building, Suite 250, University of Tennessee, Memphis, TN 38163. Applications from women and minority candidates are encouraged. The University of Tennessee is an EEO/AA/Title IX/Section 504/ADA employer. Rev. 2 (4/91).

Senior and Junior Faculty Positions in Electrical and Computer Engineering, State University of New York at Buffalo. Applications are sought to fill an expected tenured senior faculty position, and a junior position beginning September 1992. Senior applicants must have proven leadership skills in the area of Computers or Communications Engineering and have an earned doctorate. They must have teaching and research interests in one or more of the following areas: communications; photonics; expert systems; computer architecture; data structures; and parallel processing. Preference will be given to those experienced in optical communications or optical computing. Evidence of an ability to develop external funding for personal research is required. The successful candidate will have an opportunity to recommend new faculty for appointment and will be provided with funds to establish a strong research and educational program in Communications or Computer Engineering. This position will require undergraduate and graduate course development, teaching, coordination of a research program involving young faculty, interaction with existing faculty, and exploration of interdisciplinary areas of education and research. A junior position is also expected in the above area. This represents an opportunity to join a strong group of new faculty and to participate in a good environment for research and education. Applicants should supply a resume with names and addresses of three or more individuals for letters of reference. Applications should be sent to Professor Wayne A. Anderson, State University of New York at Buffalo, Department of Electrical and Computer Engineering, 201 Bell Hall, Buffalo, NY 14260, SUNY at Buffalo is an equal opportunity/affirmative action employer.

Department Head, Electrical Engineering. The University of Alabama invites applications for the position of Head, Department of Electrical Engineering. The position requires an earned doctorate in Electrical Engineering, a strong research and publication record, and demonstrated leadership capability. Administrative experience and U.S. citizenship are preferred. The Electrical Engineering program is accredited by ABET and offers B.S., M.S., and Ph.D. degrees.

It has 17 faculty positions including an Endowed Professorship in Computer Architecture and is the largest of the College of Engineering's departments. The present EE enrollment is about 460 undergraduates and 63 graduate students. In addition to modern, well-equipped EE laboratories, the College and University have excellent and extensive computer facilities available to faculty and students. The University of Alabama campus located in Tuscaloosa is the oldest and largest in The University of Alabama system with over 19,000 students. Tuscaloosa is situated in the rolling hills of West Alabama about fifty miles southwest of Birmingham. The metropolitan area has a population of about 150,000. Most winters are snowless, and the region abounds with lakes and streams. Interested applicants should send their resume to: Dr. Odis P. McDuff, Chairman, Electrical Engineering Head Search Committee, Post Office Box 870286, Tuscaloosa, AL 35487-0286, Phone: (205)348-1754. Initial screening of applicants will begin on December 2, 1991; however, applications will continue to be received and evaluated until the position is filled. The starting date will be August 16, 1992. The University of Alabama is an Equal Opportunity Affirmative Action Employer.

Electrical Engineering: The University of Portland seeks candidates for tenure track positions at the rank of Assistant/Associate Professor. Dedication to excellence in teaching is essential. Ph.D. in Electrical Engineering is required. The candidates are expected to teach undergraduate and graduate courses and to conduct professional activities in at least one of these areas: Microelectronics, VLSI design, Communication Systems, Optics and Optoelectronics. Send resume and names of at least three references to Dr. Aziz S. Inan, Chair, Electrical Engineering, University of Portland, 5000 N. Willamette Blvd., Portland, OR 97203. (503)283-7314. An affirmative action/equal opportunity employer.

The Bradley Department of Electrical Engineering of Virginia Polytechnic Institute and State University invites applications for several tenure track faculty positions. Greatest needs are in the areas of communications with emphasis on high frequency electronics, computers, fiber optics, and signal processing. Consideration will be given to applicants in all areas at the Assistant and Associate Professor level. Applicants must have an earned doctorate, be interested in undergraduate and graduate teaching, and be willing to secure research sponsorship. Virginia Tech is Virginia's land grant university offering degrees through the Ph.D. Send complete resume with references and employment/citizenship status to: Prof. W.L. Stutzman, Chairman, Faculty Search Committee, Bradley Department of Electrical Engineering, Virginia Tech, Blacksburg, VA 24061-0111. Applications will be accepted until April 15, 1992, or until suitable candidates are selected. Virginia Tech is an Equal Opportunity/Affirmative Action Employer and welcomes applications from minorities and women.

Southern Methodist University, School of Engineering and Applied Science. Department Chair, Computer Science and Engineering. Nominations and applications are invited for the position of Professor and Department Chair of the Department of Computer Science and Engineering at Southern Methodist University. Applicants must have a Ph.D. in Computer Engineering, Computer Science, or a related discipline. Candidates must have demonstrated excellence in research with a substantial grant record and a strong commitment to teaching. It is anticipated that the position will be filled by August, 1992. SMU is a private university in Dallas, Texas with approximately 8,000 students. CSE is in the School of Engineering and Applied Science, where a close working relationship exists with the Department of Electrical Engineering. The department is growing and presently has fourteen faculty positions. CSE presents a balanced program of research and education at all levels and has been offering Ph.D. degrees since 1970. The department has extensive contacts with computer and telecommunications related industrial organizations. The Dallas area is traditionally distinguished as one of the top five centers for high technology complemented by the presence nearby of the Superconducting Super Collider. Applicants should send a complete resume, including the names of three references to: Professor Ian Gladwell, Chair, CSE Search Committee, 208 Clements Hall, Southern Methodist University, Dallas, TX 75275. SMU is an equal opportunity/affirmative action, Title IX employer. Applications from women and minorities are particularly encouraged. Applications will be accepted until February 1, 1992.

Graduate Research Assistantships are available for graduate students pursuing the M.S. or Ph.D. degrees in Electric Power Systems at Clemson University. Funding is available through Clemson University Electric Power Research Associations (CUEPRA), NSF, and research contracts with power companies. Research assistantships consist of a monthly stipend and tuition fee reduction. For United States citizens, industrial fellowships are also available. For further information, contact Dr. Adly A. Girgis, ECE Department, Clemson University, Clemson, SC 29634-0915.

Assistant Professor: To teach undergraduate and graduate courses in Electrical Engineering and to conduct research. All areas of emphasis considered. Applicants must have a Doctoral Degree or expect it within six months. Send resume and a list of three letters of recommendation to Gill Richards, Chair, Department of Electrical Engineering, University of New Orleans, New Orleans, LA 70148. Completed applications received by December 10, 1991 will be given first consideration, but the search will continue until the position is filled. UNO is an equal opportunity-affirmative action employer.

University of Hawaii at Manoa, Department of Electrical Engineering, invites applicants for tenure-track associate professor or assistant professor positions with specialization in either of the following areas: (1) Computers: Advancement of knowledge and state of the art in high performance computing systems. System software or parallel and distributed algorithms to complement current faculty strengths are welcome. (2) Electrophysics: Microwave engineering and VLSI. Duties: Teach EE undergraduate and graduate courses, serve on university and department committees, conduct research and scholarly activities, and perform related tasks as assigned. Minimum Qualifications: Associate Professor: Ph.D. degree or completion of all requirements for a doctorate in electrical engineering, computer science, and/or equivalent; minimum of four years of full-time college or university teaching at the rank of assistant professor or equivalent, with evidence of increasing professional maturity; demonstrated scholarly achievement in comparison with peers active in the same field; demonstrated ability to plan and organize assigned activities, including the supervision of work of assistants when appropriate; ability to pursue and supervise research; strong commitment to both undergraduate and graduate teaching. Assistant Professor: Ph.D. degree or completion of all requirements for a doctorate in electrical engineering, computer science, and/or equivalent; demonstrated ability to teach; demonstrated scholarly achievement; ability to pursue and supervise research; strong commitment to both undergraduate and graduate teaching. Salary negotiable dependent upon qualifications and experience. Send resume and three references by November 30, 1991 to: Professor Shu Lin, Chairman, Department of Electrical Engineering, University of Hawaii at Manoa, 2540 Dole Street, Holmes Hall 483, Honolulu, HI 96822. An Equal Opportunity/Affirmative Action Employer.

Electrical and Computer Engineering. The Department of Electrical and Computer Engineering at West Virginia University anticipates possible faculty positions in all areas. Salary and rank will be commensurate with qualifications. Positions will be tenure track. Applicants must have the Ph.D., must have potential for high quality teaching, and will be expected to initiate research and participate in departmental research programs. A curriculum vitae and cover letter identifying an area of specialization should be sent to: Chairman, Department of Electrical and Computer Engineering, West Virginia University, P.O. Box 6101, Morgantown, WV 26506-6101. Applications will be received and considered immediately and searches will continue until all available positions are filled. West Virginia University is an affirmative action/equal opportunity employer m/f.

Brigham Young University, Computer Science Department Assistant Professor. Applications are invited for an Assistant Professor position in Communications/Networking, Software Engineering or related fields beginning September, 1992. Candidates must have a Ph.D. in Computer Science. Applicants should send a curriculum vita to E. Daniel Johnson, 3362 TMCB, Brigham Young University, Provo, Utah 84602. BYU is an EEO/AA employer and is sponsored by the Church of Jesus Christ of Latter Day Saints. Preference is given to LDS applicants.

University of Nebraska-Lincoln, Electrical Engineering. Seek tenure-track faculty in digital signal processing and/or communications. A second position is to be filled in area aligned with current programs. These include power systems, EM fields and radar systems, control systems, solid state materials and devices, digital systems and pulsed power. Rank and salary are commensurate with qualifications; preference is to hire at the assistant professor level. Applicants must be U.S. citizens or permanent U.S. residents and have an earned Doctorate. Minority and women candidates are strongly encouraged to apply. Send letter of application, resume, and list of three references with telephone numbers, by February 1, or until a suitable candidate applies thereafter, to: Dr. R.J. Soukup, Chair, Department of Electrical Engineering, University of Nebraska-Lincoln, Lincoln, Nebraska 68588-0511. Affirmative Action/Equal Opportunity Employer.

Head, Dept. of Electrical and Computer Engineering Carnegie Mellon University. Nominations/Applications are invited for the position of the Head of the Department of Electrical and Computer Engineering at Carnegie Mellon University. Currently, the department has 35 faculty members, 160 Ph.D. students, 90 M.S. students, and 400 undergraduate students. With a newly developed, highly flexible B.S. degree program in Electrical and Computer Engineering, the department is a leader in engineering curricular reform and innovation. The department has an annual research budget of $13.5 million and is home to: an NSF Engineering Research Center in Data Storage Systems, the SRC-CMU Research Center for Computer-Aided Design, the Pennsylvania SEMATECH Center of Excellence (SCOE) for Rapid Yield Learning, the Center for Excellence in Optical Data Processing (CEODP), the Center for Dependable Systems (CDS), the Laboratory for Automated Systems and Information Processing (LASIP), and a concentrated research effort in Solid State Materials and Devices. The department also has strong research ties to the School of Computer Science, the Robotics Institute and the other CMU NSF Engineering Research Center, the Engineering Design Research Center (EDRC). The research facilities available include extensive computational facilities including access to several supercomputers at the Pittsburgh Supercomputing Center, a 4000-square feet class 100 clean room, recently renovated Solid State Research Laboratories, Data Storage Systems laboratories as well as Optical and Digital Processing laboratories. The successful candidate should have an earned Ph.D. in Electrical/Computer Engineering or related fields, an internationally recognized research stature and the experience and abilities to lead the teaching and research excellence of the department. Nominations/Applications, along with a vita and the names, addresses and phone numbers of three references should be sent to: Professor B.V.K. Vijaya Kumar, Chairman, ECE Department Head Search Committee, Department of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, PA 15213-3890. The search committee will consider all applications and nominations received up to February 1, 1992. Carnegie Mellon University is an affirmative-action, equal opportunity employer.

University of Houston. The Department of Electrical Engineering invites applications for tenure-track positions in the areas of applied electromagnetics, biomedical engineering, communications, computer engineering, elec-

tronics and microelectronics. Openings are available at all ranks. Please send resumes to Dr. J.C. Wolfe, Department of Electrical Engineering, University of Houston, Houston, TX 77204-4793. An Equal Opportunity Employer.

Gonzaga University in Spokane, Washington is seeking a faculty member with expertise in the areas of Electro-magnetics, Electronics and materials. Responsibilities include teaching in an ABET accredited BSEE program and an MSEE program. Preference will be given to an individual with some industrial design experience. An appointment will be made at the assistant or associate professor level unless the preferred candidate is exceptionally well qualified. Only permanent residents and citizens of the United States will be considered. Candidates must have or have nearly completed a Ph.D. degree by the appointment date. Gonzaga University is a Catholic, Jesuit institution with a commitment to teaching humanistic values to develop the whole person. The attractive, growing campus is set in an area of scenic beauty in the Inland Northwest. Send resume and list of three references to Dr. R.A. Birgenheier, Chairperson, Department of Electrical Engineering, Gonzaga University, 502 E. Boone St., Spokane, WA 99258. Screening of applicants will begin January 2, 1992 and the expected appointment date is August 30, 1992. Gonzaga is an Equal Opportunity/Affirmative Action Employer.

Loyola College in Maryland: The Department of Electrical Engineering and Engineering Science has a tenure-track position at the assistant professor level available Fall 1992. Candidate should have a Ph.D. in Electrical/Computer Engineering and a commitment to excellence in teaching as well as continuing research. Experience in digital systems, control theory, and engineering design is desired, although qualified applicants in other areas will be considered. The Department offers an ABET-accredited Bachelor of Science in Engineering Science Degree with concentrations in electrical science, digital science, and materials science. The Department is in the process of developing a Bachelor of Science in Electrical Engineering Degree program; the first BSEE degrees were awarded in May 1991. In addition, the Department jointly offers, with the Computer Science Department, a graduate program leading to a Master of Engineering Science with concentrations in electrical engineering, computer engineering, and computer science. Loyola College is a private, comprehensive university, with a strong tradition in the liberal arts and is located in suburban Baltimore. Send resume to: Dr. Paul Coyne, Jr., Chair, Department of Electrical Engineering and Engineering Science, Loyola College, 4501 N. Charles Street, Baltimore, MD 21210-2699. EOE.

San Jose State University Electrical Engineering Department. Applications are invited for entry-level tenure-track faculty positions at the Assistant Professor rank. Positions are available in computer and multiprocessor design, microprocessor applications; microelectronic VLSI/ULSI circuit design; semiconductor devices and technologies; circuits, systems and computer communications networks. Earned doctorate in Electrical Engineering is required. Positions are limited to U.S. citizens or permanent residents. Research, consulting and summer employment opportunities are available. The University is the oldest and one of the largest in the California State University System. It is located at the southern end of San Francisco Bay in the heart of Silicon Valley. Resume and names and addresses of three references should be submitted to Dr. Ray R. Chen, Chair, Department of Electrical Engineering, San Jose State University, San Jose, California, 95192-0084. San Jose State University is an equal opportunity/affirmative action/Title IX employer. Women and minorities are especially encouraged to apply.

The Department of Electrical Engineering and Computer Engineering invites applications for several anticipated tenure-track faculty positions. Applicants at all ranks will be considered. Starting dates are negotiable with preference given for fall 1992. Primary needs are for specialization in the areas of communications, signal processing, controls, computer networks, distributed computing, data communications, microelectronics and VLSI design. Responsibilities include teaching, research and outreach. Salary and rank are commensurate with qualifications and experience. Requirements include a doctorate degree with a demonstrated potential for success in research and a commitment to teaching. Applicants should send a resume with a statement of teaching, research, and outreach interests, as well as a list of at least three (3) references to: Chairman, Faculty Search Committee, Department of Electrical Engineering and Computer Engineering, Iowa State University, Ames, Iowa 50011. Iowa State University is an Equal Opportunity/Affirmative Action Employer.

California State University, Los Angeles—Department of Electrical and Computer Engineering seeks tenure track faculty with experience and expertise in Computer Hardware and Architecture. PhD required for aware of tenure. Industrial experience highly desirable. Apply to Dr. Martin S. Roden, Chair, Electrical and Computer Engineering, California State University, Los Angeles, CA 90032. Deadline for first consideration is January 2, 1992. An Equal Opportunity/Affirmative Action/Handicapped/Title IX Employer.

Carnegie Mellon University. Graduate Study in Engineering and Public Policy (EPP): The EPP Graduate Program leads to a research-based Ph.D. specializing in policy issues in areas such as: telecommunication, computer and other information technologies; design and application of conventional and AI-based computer systems for policy analysis and decision support; mathematical modeling of energy and environmental systems; technical and economic issues of peace and international security; manufacturing and industrial policy; and risk analysis. Applicants must hold a Bachelor's Degree in engineering, physical sciences, or mathematics. Education or experience beyond the Bachelor's Degree is very desirable. Contact Dr. Indira Nair, Engineering and Public Policy (06), Carnegie Mellon University, Pittsburgh, PA 15213.

Dean of the Florida A&M University/Florida State University College of Engineering. Florida A&M University and Florida State University, located in Tallahassee, are members of the State University System and have enrollments of 9,000 and 28,000 respectively. A joint College of Engineering, which serves both universities, was established in 1982 and offers baccalaureate, masters, and doctoral degrees. The Dean, reporting directly to the provosts of the two universities, serves as the chief administrator of the College of Engineering. The FAMU/FSU College of Engineering consists of 50 faculty members serving 1600 undergraduate and 200 graduate students in five academic departments: Chemical, Civil, Electrical, Industrial, and Mechanical Engineering. The College offers ABET accredited undergraduate programs in Chemical, Civil, Electrical, and Mechanical Engineering. Candidates should have an earned doctorate in engineering or a related discipline, a significant record of both scholarly achievement and sustained research activity sufficient for appointment at the rank of a professor in one of the departments of the college, experience in engineering education and administration, vision and capability to successfully develop academic and research opportunities, strong communication and human relation skills, and demonstrated ability to work successfully in programs that serve significant minority and women populations. Submit supporting materials including a resume and names of five references to Professor Anjaneyulu Krothapalli, Chair of Search Committee, Department of Mechanical Engineering, FAMU/FSU College of Engineering, P.O. Box 2175, Tallahassee, Florida 32316-2175. The deadline for applications is February 15, 1992. The anticipated starting date is July/August 1992. Women and minorities are encouraged to apply. Florida A&M University and Florida State University are both Affirmative Action/Equal Opportunity Employers.

Concordia University Department of Computer Science. The Department invites applications for an immediate opening in the rank of Research Assistant Professor. The appointee will be associated with the expert systems research group in our Centre for Pattern Recognition and Machine Intelligence (CENPARMI). The area of specialization should be in Verification and Validation of Expert Systems. Candidates should have a Ph.D. and proven research records in the above area. Ability to conduct independent research and lead projects are considered important assets. Interested applicants should send resume, reprints of publications and the names of at least three referees as soon as possible and before December 31, 1991 to Chair, Personnel Committee, Department of Computer Science, Concordia University, 1455 de Maisonneuve West, Montreal, Quebec H3G 1M8, Canada. In accordance with Canadian immigration requirements, priority shall be given to Canadian citizens and permanent residents of Canada. Concordia University is committed to employment equity and encourages applications from women, aboriginal peoples, visible minorities and disabled persons. All things being equal, women candidates shall be given priority.

Electrical and Computer Engineering. Tenure track faculty position at the assistant professor rank in the area of parallel digital optical computing systems. Candidates must have an earned doctorate in computer engineering. Education or experience should lie in optical computing systems design with background in optical architectures for high-speed numerical as well as symbolic artificial intelligence computing, optical interconnects for multiprocessors, optical communication protocols and optical associative processing. Research areas of interest can include optical information processing, optical processors design, computer architectures for optical implementations, and modelling and analysis of optical systems. Duties include: 1) teaching undergraduate and graduate courses on optical computing techniques, computer architectures, parallel processing, optical interconnection networks, software design, and modelling and simulation of optical systems, etc.; 2) advising B.S., M.S., and Ph.D. students; 3) research on high performance optical processing systems, particularly for artificial intelligence applications, high-speed optical interconnection networks for parallel computers, and high-speed optical protocols; 4) development of a significant sponsored research program. Qualified applicants send resume or application letter with ad and three reference letters by November 20, 1991 to: AZ DES Job Service Attn: 732A RE: 4665216, P.O. Box 6123, Phoenix, AZ 85005 (Job Location: Tucson, AZ), Emp. pd. ad. Proof of authorization to work in U.S. required if hired.

Lehigh University—Department Chairperson with Endowed Professorship. Nominations and applications are invited for the position of Chairperson and Chandler-Weaver Professor of the Department of Computer Science and Electrical Engineering, College of Engineering and Applied Science. We are seeking candidates with a record of distinction in university teaching and research and a devotion to quality undergraduate and graduate education. The successful candidate must have a demonstrated potential for academic administration and leadership, and have a strong commitment to furthering the research endeavor in the Department and to building a nationally recognized graduate program. The Department offers B.S. and M.S. degrees in Electrical Engineering, Computer Engineering, and Computer Science; and Ph.D. degrees in Electrical Engineering and in Computer Science. It is the largest department in the College of Engineering and Applied Science and awards annually about one third of Lehigh's engineering degrees at the undergraduate and graduate levels. The University is located in eastern Pennsylvania, a short distance from New York City and Philadelphia. The position will be available at the start of the 1992-1993 academic year. Please send application (with at least three references) or nominations addressed to Professor Kenneth K. Tzeng,

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NEW SELF-STUDY COURSE FOR 1991: PARALLEL PROCESSING

The IEEE Educational Activities Department has recently released an exciting new self-study course in parallel processing to address this state-of-the-art microprocessor technology. The program offers practical, in-depth information on both the design and the programming aspects of parallel processing. The programming of parallel machines and ways of thinking in parallel are illustrated through examples, and the pros and cons of design alternatives are discussed.

Designed for systems designers, applications engineers, programmers, computer scientists, or mathematicians seeking knowledge in this field, this course consists of a comprehensive study guide, a question-and-answer workbook, a final exam, and a text, *Advanced Computer Architecture*, by Dharma Agrawal.

For more information on this course and other self-study courses, call 908-562-5498, or CIRCLE # 71 on the Reader Service Card.

'ENGINEERS FOR EDUCATION' SEEKS TO PLACE 100 000 ENGINEERS BY YEAR 2000

IEEE members are being sought to participate in "Engineers for Education," the private sector's largest voluntary effort in support of education in the United States today.

The IEEE and 44 other scientific and technical societies formed the National Coalition of Engineering Societies for Precollege Mathematics and Science Education, and this group launched the program early this year to attract 100 000 volunteer engineers to assist in improving math and science education in classrooms nationwide.

In a Feb. 19 kickoff ceremony at the White House, President Bush said: " 'Engineers for Education' will play a key role in helping achieve our national goal of math and science excellence by the year 2000." Some 1000 volunteers have enlisted in the last six months.

IEEE members who are interested in participating in the program can obtain registration materials by calling the coalition at 800-489-0348. The kit provides details about typical outreach activities, including ongoing efforts of the member societies.

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A program disk containing many complex computations serves as a valuable reference tool providing long-term support. The course contains a study guide, answer book, program disk, final exam, and a textbook, *The Calculus Tutoring Book*, by Carol and Robert Ash, IEEE Press.

For more information on this course and other continuing education materials, call 908-562-5498, or CIRCLE 76 on the Reader Service Card.

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Search Committee Chairperson, Department of Computer Science and Electrical Engineering, Packard Laboratory #19, Lehigh University, Bethlehem, PA 18015. Lehigh University is an Equal Opportunity/Affirmative Action Employer.

Electrical Engineering Faculty Position—The Purdue University School of Engineering and Technology at Indianapolis invites applications for tenure track positions as Assistant/Associate Professor rank in the areas of Signal and Image Processing, Communications, and Computer Engineering. Application must hold an earned Ph.D. in Electrical Engineering, or Computer Engineering. Applicants are expected to have a strong commitment to teaching at the undergraduate and graduate levels, and establish a strong research program. Rank and salary are highly competitive and based upon experience and qualifications. The School of Engineering and Technology is one of sixteen schools of Indiana University-Purdue University at Indianapolis with over 28,000 students and 160 academic programs. The Department currently has collaborative research programs with Indiana University School of Medicine and the Purdue University School of Science at Indianapolis, both located on campus. Applications which include complete resume and names, addresses, and phone numbers of three references should be sent to: Dr. H.O Yurtseven, Department of Electrical Engineering, 723 W. Michigan Street, Indianapolis, IN 46202-5132, by January 17, 1992. The University is an equal opportunity/affirmative action employer.

Chair, Electrical Engineering—The Purdue University School of Engineering and Technology at Indianapolis invites nominations and applications for the position of Chair of the Department of Electrical Engineering. Applicants must hold an earned Ph.D. in Electrical Engineering with strong commitment to undergraduate and graduate teaching as well as a proven record of scholarly research appropriate for appointment at full professor level. Candidates are expected to have good communication skills, administrative experience and clear vision to guide and expand the department during the next decade. The School of Engineering and Technology is one of sixteen schools of Indiana University-Purdue University at Indianapolis with over 28,000 students and 160 academic programs. The Department of Electrical Engineering is currently undergoing a substantial two-phase expansion that will be completed in 1993. Candidate interviews are scheduled to begin in February 1992. Applications which include complete resume and names, addresses and phone numbers of three references should be sent to: Dr. H.O. Yurtseven, Department of Electrical Engineering, 723 W. Michigan Street, Indianapolis, IN 46202-5132. The University is an equal opportunity/affirmative action employer.

The Electrical and Computer Engineering Department at George Mason University is seeking applicants for tenured or tenure-track positions. The principal area of opportunity is computer engineering, in particular computer architectures and VLSI. Other areas of emphasis within the department include communications, robotics and control, and electronics. Our undergraduate program is accredited. We have a strong Masters program and we are part of the interdisciplinary Ph.D. program in Information Technology along with the other departments of the school of Information Technology and Engineering: Computer Science, Operations Research and Applied Statistics and Systems Engineering. Candidates must have an earned doctorate in engineering. Rank and salary will be commensurate with the applicants qualifications. Applicants must be committed to quality graduate and undergraduate teaching and developing a strong research program in their area of interest. Applicants should send their resume to Dr. Andre Manitius, Chairman of the Search Committee, Electrical and Computer Engineering Department, George Mason University, Fairfax, VA 22030. Equal Opportunity/Affirmatve Action Employer.

Chair, Systems Engineering Department (Systems and Industrial Engineering). Nominations and applications are invited for the position of chair of the Systems Engineering Department, Case Western Reserve University, Cleveland, Ohio. Candidates must have at least one degree in Industrial Engineering and be eligible for the rank of professor in Industrial or Systems Engineering. Candidates should have a strong record in research, a dedication to quality education, and possess excellent leadership skills. The department offers BS (ABET accredited), MS, and PhD degree programs in Systems and Control, and the BS in Industrial Engineering. An important objective is to strengthen and expand the I.E. component of the department and candidates must be committed to realizing this objective, as well as providing leadership for the department as a whole. The department boasts a strong and dedicated faculty with expertise in control and systems theory, process control, systems analysis, and production and manufacturing systems, with focus on both theory and applications. There is a broad involvement in research, including many interdisciplinary projects with other departments and centers. More detailed information may be had on request. Correspondence should be directed to Prof. Irving Lefkowitz, Search Committee Chair, 611 Crawford Hall, Case Western Reserve University, Cleveland, Ohio, 44106. CWRU is an equal opportunity/affirmative action employer.

Government/Industry Positions Open

Help Wanted—Elec. Eng. EE Bach. deg. & 3 yrs. exp. in high temp. RTD sensors req. Exp. must inc. set up of production line. Dev. & build prod. lines for RTD elements, upper limits to 1500 C. Build & test probes for ability at same temp. Determine drift at high temps. Build strain-free element. Train tech. Submit reports, write papers for symposiums. 8:30 a.m.-5:30 p.m. $36,500/yr. Resumes to: Dick Hewetson, #1-157, MDJT, 390 N. Robert St., St. Paul, MN 55101.

Parts Reliability Engineer, for Automotive Electronics Manufacturing Firm: 40 hours per week, 7:30 a.m. to 4:30 p.m. Mon.-Fri., overtime as needed, $3,450.00 per month basic plus $29.85 per hour overtime. Duties include review of new part drawings and prepare part specifications for flexible circuits, bulbs, and electronic assemblies, develop test plans and qualify parts, provide application assistance and resolve part problems, develop reliability testing for electronic modules, upgrade the image processing system, develop an automated vision system for bulb measurements. Must have M.S. degree in Electrical Engineering and two and one half years experience in Electrical Engineering which may be gained either in the field or as an instructor, and must include use of computer application and programming. Must have knowledge of color measurement and technology as demonstrated by two and one half years included in the on the job experience or at least two publications on the subject. This is an employer paid ad. Send resumes to: 7310 Woodward Ave., Room 415, Detroit, Michigan 48202. Reference No. 55291.

Application Engineer—For Roanoke, VA area emp. resp. eng. of auto. drive control hdwr. & sftwr. products for paper manu. equip.; interface w/customer and detail eng.; translate cust. requirements into application eng. definitions & prep. of sys. specs. Must have BS or equiv. in elec. eng. w/8 yrs. wrk. exp. in application eng. in paper ind. proc. and exp. w/comp. AC&DC motor control circuit and sftwr., power conv. circuit and delivery sys.; control theory of motors and feedback control sys.; knowl. of func. and operation of paper manu. machines 40hrs/wk. 8:00-4:45, $56,000.00/yr. No OT. To apply: mail or hand carry res. w/copy of ad attach to: VEC, Dept. 3008, 1202 Franklin Rd. Rke, VA 24002-0061, JO #VA0043727 EEOE.

Electrical Engineer for firm in northern Ohio. Fabricating hardware and writing software for factory automation. Must have B.S. in Electrical Engineering and academic program must have included the following courses in the areas of: Robotics, Control Systems, Systems Simulation, Computer Algorithms, Active Circuits, and Microprocessor Interfacing. Must have 6 mos experience as computer programmer or electrical engineer. Must be conversant with statistical process control, programmable controllers and automatic control systems, as evidenced by academic letter(s) of reference and/or employer testimonial(s). 40 hrs/wk, 8am-5pm, $29,750/yr. Must have proof of legal authority to work permanently in U.S. Send resume and course transcript in duplicate (no calls) to J. Davies, JO# 1302889, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, Ohio 43216.

Computer Engineer for software service firm in central Ohio. Development of new system designs through computer modelling and system simulation. Develop methods to improve voice response capability through use of digital signal processing techniques. Application of queuing theory in communication protocol design. Develop communication software testing tools for newly designed systems. Develop & monitor tests for physical networks to assure accuracy of system circuitry. Object is to develop new computer interface & communication protocol for local scientific area telecommunication network. Extensive use of Unix & C language. Applicants will qualify with Masters in either Computer Science or Electrical Engineering. In addition applicant must have either 1 yr. exp. in job described or 18 mos. in Computer Software Development, Design & Testing in Unix & C which includes 6 mos. exp. in modelling & simulation analysis & development which may be at graduate research level. 40 hrs/wk., 8 AM-5 PM, Mon-Fri, $41,000.00/yr. Must have proof of legal authority to work in the U.S. Send resume in duplicate (no calls) to J. Davies, JO#1260317, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, OH 43216.

Projects Manager, Metals Industry. For Roanoke VA area emp. to lead major projects incl. bid inquiry, proposals, app. eng., prod. eng., manu., test, start up, commissioning and acceptance of metals ind. mill auto. equip. incl. hot strip mills, tandem cold mills and large process lines., sys. dev., costing, resource ident., scheduling, management and troubleshoot involved. Must have BS in Elec. Eng. w/8 yrs. wk. exp. in metals ind. auto control eng. & knowl. AC&DC drives, prog. controllers, dig. communications links, sys. & high level des. & finance and commercial negotiation exp. 40 hrs/wk. hrs. 8:00-4:45, $71,000/yr. No OT, to apply: mail or carry res. w/copy of ad to: VEC, Dept. 3008, 1202 Franklin Rd., Roanoke, VA 24002-0061, J.O. #VA1071989.

Electrical engineering researcher: research for modeling, design & analysis for recording heads & systems, micromagnetics, spec. domain stability in thin film inductive & magnetorisistive heads (analytical & exper.), dev. software for modeling, write code for 2D & 3D nonlinear magnetostatic anal. & for eddy current simulation & combined head-media simulation. Fortran & C. Must have knowledge of numerical analysis as applied to magnetic fields. Ph.D., E.E. or Comp. Eng. $54,642/yr. 40 hrs. per week. Job site & interview: Goleta, CA. Send this ad & resume to Job #PM10461, P.O. Box 9560, Sacramento, CA 95823-0560 not later than 11/30/91.

Software Engineer; 40 hrs/wk.; 8am-5pm; $720/wk. Job requires: Master's degree in Electrical Engineering. Job also reqs.: 1) Grad. level research in higher level mathematics problem solving evidenced by Master's thesis or 1 published paper; 2) 1 college course covering Fortran & Pascal computer languages; 3) 1 grad. crse. in computer design; 4) 1 grad. crse. in numerical analysis; and 5) 1 grad. crse. in system theory. Job duties: Develop a Windows (TM)-based analysis system written in an object-oriented programming language for various analytical instruments manufactured by corporation. Analytical instruments must be capable of data analysis, data linearization, and graphics display. Research new directions for other graphical user interface softwares. Apply numerical analysis techniques to analytical instruments. Qualified applicants should send resume & verification of reqs. to 7310 Woodward, Rm. 415, Detroit, MI 48202. Ref. #67991. Employer Paid Ad.

Electrical Engineer wanted. Duties: Design & diagnose electrical control circuits for automated equipment such as material handling systems, filtration systems & specialized machine tools; estimate labor & material requirements for electrical engineering construction proj-

ects; write computer programs using Basic, Fortran & Assembly machine language; design safety features for equipment that meets Corporate, State & Federal regulations; use CAD/CAM software such as AutoCAD. Requirements: Bachelor's in Electrical Engineering, 18 mos. exp as Electrical Engineer (a/k/a Co-op student). Related exp. must include: designing trouble-shooting electrical control circuits for automated equipment such as material handling systems, filtration systems & specialized machine tools; designing & trouble-shooting control circuitry for above equipment; estimating labor & material requirements for electrical engineering construction projects; writing computer programs using Basic, Fortran, & Assembly machine language; designing safety features for equipment that meets Corporate, State & Federal regulations; using CAD/CAM software such as AutoCAD. All the related exp. must have been obtained in the automotive industry. Pay is $37,000 per yr. 40 hr/wk. Resumes to 7310 Woodward Ave., Rm 415, Detroit, MI 48202. Ref. #70791. Employer Paid Ad.

Electronics Eng.—Apply numerical techniques to solve electromag. boundary-value problems & to implement dual mode dielectric resonator filters & multiplexers. Dev. up/down converters, high power & low noise amps & dielectric resonator oscillators using Touchstone & Super Compact. Perf. theoretical anal. of effects device non-linearity, phase noise, interference, & other channel impairments on receive S/N ratio. Knowl. of stochastic processes, info., theory, scattering parameters & HP 8510 netwk. analyzer. Exper. in Fortran & C in Sun/Sparce workstation & IBM PC under Unix & DOS. Rqmts: M.S. in Electronics Engr. & 18 mo. exp. in Electronics Eng. or as Research Asst. in Elec. Engr. field. M-F; 40 hr/wk., 8:30-5:00; Sal. Range: $42,000/yr. Mail resume & copy of ad to MD DEED, 1100 N. Eutaw St., Rm. 212, Balto., MD 21201; JO #9048685; Job Loc: Clarksburg, MD.

Electrical Engineer for computer firm in Kettering, Ohio. To design and develop the Object Oriented Multiple Channel Traffic Pattern and Signal Computer Real Time Control System with variable Statistical patterns and system self-adapting functions by using huge system error analysis, computer aided self-adapting multiple variable control, probability statistical analysis, semi-conductor converting, computer language C++, computer interface and indectance sensor design technologies. Qualifications: BS in EE, 2 yrs. related exp. in EE or Teaching, which must include 1 yr exp. in huge system error analysis, computer aided self-adapting multiple variable control theory, probability analysis, semi-conductor converting, computer language C++, computer interface and indectance sensor design. 40 hrs/wk, 9am-5pm, Mon.-Fri., $34,400/yr. Must have proof of legal authority to work permanently in US. Send resume in duplicate (no calls) to J. Davies, JO#1290276, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, OH 43216.

Manufacturing Engineer, to design and develop electrical and mechanical engineering systems related to amorphous silicon photovoltaic production and operation; Installation, testing, and operation of small and large area photovoltaic systems and subassemblies; Supervise all engineering aspects of production of concept from production, including balance of systems. Master of Science degree in Electrical Engineering required plus either 4 years experience in job offered or 4 years experience as Technical Manager. Experience must encompass all aspects of amorphous silicon photovoltaic processing, including: Installation, design, development, and operation of photovoltaic systems; and computer interfacing and programming related to qualification, manufacturing, and quality-control testing of complete systems. Annual salary $50,000.00 for 40-hr. week. 8:30 a.m. to 5:30 p.m. Send resumes and transcripts to 7310 Woodward Avenue, Room 415, Detroit, Michigan 48202. Ref. No. 71091. Employer paid ad.

Engineer, Software: Req. Ph.D. in EE or CS and graduate research in object oriented & KBS advanced design methodologies; C, Unix, and software development implementation practices required. To design and implement software for Sun and SPARC- based computer workstations, utilizing advanced design methodologies. $64,000/yr. Job site/interview: Mountain View, CA. Clip ad and send with resume no later than December 1, 1991 to Job #JJ 23316, P.O. Box 9560, Sacramento, CA 95823-0560. Upon hire must show immediate ability to work in the United States. EOE.

Analog/Digital VLSI Designer at the Superconducting Super Collider. The Physics research division at the SSC laboratory in Dallas has an opening available for an Analog/Digital Custom VLSI Designer. Responsibilities include: Design of mixed analog/digital custom chips in CMOS and BICMOS for the readout of SSC detectors for clock rates of 63 MHz and analog bandwidth up to 300 MHz; Simulation, layout and verification with advanced integrated software; Communications with foundries; Development of test procedures and participation in testing in an R&D environment. Applicants must have a degree in engineering, computer science or physics and minimum 5 years experience in VLSI design at the transistor/gate/cell level, simulation and layout, 2 of which in analog design. Familiarity with low power, low noise and rad-hard is a plus. Experience with Unix and C is desired. Send cover letter, resume and salary history to: SSC Laboratory, MS-2050/3223-FH, 2550 Beckleymeade Ave., Dallas, TX 75237. Fax: 214/708-5081. An Equal Opportunity/Affirmative Action Employer.

Electrical Design Manager—Cleveland, OH Mftr. Responsible for management of technical and design team responsible for the design, production planning, and manufacture of electronic instruments for domestic and export applications. Directs personnel in fabrication of test and control equipment, determines procedures for testing products, supervises installing and maintenance of electronic equipment in the field. Must be able to read, write and speak at least one Middle East language and be able to travel to the Middle East approx. 15% of the time. A BS in electrical engineering plus eight yrs. exp. including at least five yrs. management is required. Must have three yrs. of European electrical/electronic design exp. Must have proof of legal authority to work permanently in U.S. Salary $48,000/yr. 40 hrs/wk. Send resume in duplicate (no calls) to S. Holton, JO# 1255783, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, OH 43216.

AECOM, a one-half billion dollar Consulting Engineering group has exceptional opportunities for Electrical Engineers in the following areas: New York, NY: Requires experience in power distribution, communications, standby power generation, fire alarm systems and related codes. Must have knowledge of PC based CAD Systems. BSEE and PE required. Contact: Judith Paul, Frederic R. Harris, Inc., 300 East 42nd Street, New York, NY 10017. Phone (212)972-3028 Fax (212)953-0399. Orange, CA: Requires BSEE, PE and Min: 15 years design experience with low and medium voltage power distribution, PC based short circuit analysis and relay coordination studies using Dapper/Captor. Will involve editing Corps of Engineers guide spec. Require extensive knowledge of National Electrical Code. Contact: Della Gilliland, Holmes & Narver, Inc., 999 Town & Country Rd., Orange, CA 92668. Phone (714)567-2524 Fax (714)543-0955. Albuquerque, NM: Requires BSEE and PE, design experience with commercial and government facilities, critical power distribution, special signal systems and grounding for electronic systems. Contact: Retha Shiplet, Holmes & Narver, Inc., 6501 Americas Parkway, NE Suite 700, Albuquerque, NM 87110. Phone (505)889-4104 Fax (505)884-7231.

Senior Electrical Engineer. To be involved in improving scanning tunneling microscopy (STM) and atomic force microscopy (AFM). Ph.D. in Electronic Engineering, 1 year of experience in the field or 1 year of experience in image processing. Experience or coursework must include: 1) signal and image processing development, surface topography analysis of materials; 2) pattern recognition using real-time vision module associated with a microprocessor, 3-dimensional histogram and local histogram analysis for chromatic image segmentation and colored object identification; 3) Vax 780, MicroVax, IBM/PC, Unix, IBM3090, languages C, assembly 680xx. $40,000 per year. Full time. Send resume to: Robin Sobey, Human Resources Manager, Angstrom Technology, 1815 W. 1st Ave., Suite 102, Mesa, AZ 85202.

Jr. Electrical Project Eng. wtd to provide eng. and tech. support for various projects in the development of eng. design in power distribution and elect. systems including computer analysis and programming for the projects; prepare drawings; and, write reports; Requires B.S. in Elect. Eng. and B.S. level courses, 1 each in: Electromechanical Energy Conversion, Switching Circuits, Communication Theory, and Logical Design Computer; $31,000.00/yr; 40 hrs./wk. Send resume to 7310 Woodward Ave., Room 415, Detroit, MI 48202. Ref #57191. Employer Paid Ad.

Software Engineer for research, development, & mfg. firm in NE Ohio to design, implement & maintain software for Nuclear Medicine Image Diagnostic system. The engineer will work on the software of real-time motion control for gamma camera & patient table, data acquisition, image processing & reconstruction, graphical interfaced applications. This also involves computer interface, data communication & network, image database software. All works utilize C & Motorola 68000 Assembly computer languages under UNIX operating system & X window environment. Must have an M.S. in Computer Science or Engineering with graduate level courses in Computer Algorithm, Graphics, Database Management, & Operating System. Must have 1 year exp. in design, development & implement real-time motion control software. Experience in image processing & reconstruction, computer hardware & electrical engineering are required. 40 hrs/wk, 8am to 5pm, Mon-Fri; $34,000/yr. Must have proof of legal authority to work permanently in U.S. Send resume and courses transcript in duplicate (no calls) to S. Holton, JO# 1255800, Ohio Bureau of Employment Services, PO Box 1618, Columbus, OH 43216.

Assistant Research Scientist. The Recording and Research Center of The Denver Center for the Performing Arts invites applications for the position of Assistant Research Scientist. Candidates should have a Ph.D. in Electrical Engineering, Physics, or related discipline with emphasis on time series analysis and nonlinear dynamical systems; familiarity with VMS systems, Fortran, and C; demonstrated ability to initiate, carry out and publish independent research. The Assistant Research Scientist will participate in research toward standardization of acoustic methods for voice analysis. Applicants should send two copies of vitae and letter to Ingo R. Titze, PhD., Director of Research, The Recording and Research Center, 1245 Champa St., Denver, CO 80204.

Senior Electrical Engineer. A Manufacturer and Designer of Electrical Control Panels and Automation Systems seeks worker. Duties include engineering design of electrical control panels and automation systems; estimating job cost; follow-up with field installation and close out costing; autocad and computers. Work schedule: 7:00 a.m. to 5:30 p.m. Mon.-Fri., plus additional overtime hours on weekends as requested. Total 58 hours per week. Rate of pay: $14.16/hour for regular 40 hour week and $21.24/hour for overtime hours. Applicants must have a 4 year college education with a degree in electrical engineering which must have included two (2) courses of Control Systems; two (2) courses of Protective Relays and two (2) courses of Electric Energy Systems Engineering. Employer Paid Ad. Qualified applicants send resume to: 7310 Woodward Avenue, Room 415, Detroit, MI 48202, Reference No. 50591.

Quality Engineer. Lead a division electrostatic discharge control (ESD) program, develop procedures & guidelines, research materials & products, teach and consult in ESD. Build factory simulation models and perform analysis to optimize process efficiency, throughput, mate-

rial handling, flexibility and automation while reducing WIP. Develop procedures and tools to streamline the factory's build scheduling process. Design factory layouts to improve process flow. Research and recommend process planning and analysis tools to help manage inventory tracking, shop scheduling & loading, statistical process control & process capability studies, and equipment & people planning. Requires Master of Engineering in Industrial Engineering degree with at least 2 courses in optimization/linear programming, 3 in production and inventory control, 3 in statistics, 1 in game theory, 1 in facility layouts and materials handling, 2 in accounting & finance, 2 months experience in Master Production Schedules, and knowledge of database management, Pascal, XCELL+, SAS, Minitab, and Lindo. 42.5 hrs. M/F., 8:30 a.m. to 5 p.m., $43,800 per annum. Applicants must have proof of legal authority to work permanently in U.S. Send resume and transcripts to the Idaho Department of Employment, Employment and Training Programs Bureau, 317 Main St., Boise, ID 83735. Job Order No. 6050375.

Plant Electrical Engineer. United Power Association, a rural electric cooperative headquartered in Elk River, Minnesota, has an immediate opening for an Electrical Engineer. Position responsibilities include engineering analysis of plant operating deficiencies, design and coordination of plant improvement projects and preparation of plans and specifications. Position requirements include a related engineering bachelors degree or the equivalent, ■ minimum of five years related engineering experience, including three years experience in a fossil-fired plant, as well as demonstrated communications skills. Progress towards the professional engineering license, as well as experience with plant electrical systems, switchgear and controls ■■ desirable. UPA offers ■ starting salary commensurate with qualifications, and a comprehensive benefits program. For confidential consideration, please send your resume including salary history to: Administrator, Employment and Training, United Power Association, P.O. Box 800, Elk River, Minnesota 55330-0800, 612-241-2222. Equal Opportunity Employer.

Engineer, Senior Design. Design high-performance data communication chip sets for modems; conduct chip set architecture definition & partitioning; design Sigma-Delta A/D converter, converter decimation filter & bus interface for communication with system processor; develop architecture for subsequent generation communication products. Ph.D. in Electrical Engineering. Academic project/research background in VLSI architecture design for high-speed data communication circuits, decimation filter design for A/D converter, digital signal processing, including trellis codes & viterbi decoding, voiceband modern modulation techniques & protocols, switched capacitor filter design, circuit design, Pascal and Unix; academic coursework in IC engineering, VLSI systems, digital communication & microprocessor electronics. $4,416/mo.; 40 hrs./wk. Place of employment and interview: Folsom, CA. If offered employment, must show legal right to work. Send this ad and your resume to: Job No. JJ23312, P.O. Box 9560, Sacramento, CA 95823-0560 not later than December 1, 1991. The company is an equal opportunity employer and fully supports affirmative action practices.

Engineer for TV/Video Broadcasting & Production firm in Columbus, Ohio. B.S. Engineering + 2 yrs exp. Must have 2 yrs exp w/TV Engineering, Electronics & Computerized System Analysis, and TV broadcasting equipments, & able to read & write Chinese. Acquisition, installation & maintenance or modification of studio broadcasting system, computer/video interactive equipment. Testing & evaluation of broadcasting equipment. Direct activities of layout & design of broadcast equipment, specification & safety regulations. Establish standard procedures for operation & maintenance of studio. Remote control satellite transmission equipment, Up/Down link relay system & Electronic News Gathering, Electronic Field Production Systems, Modify & design software to transfer Chinese Character generator into English character generator. 40 hrs/wk. 9am-5pm, $32,680/yr. Proof of legal authority to work permanently in U.S. req'd. Send resume in duplicate to J. Davies, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, OH 43216. No Calls. JO #1260322.

Project Engineer—Design, initiate and define process control systems used in juice blending, pasteurizing and filling processes. Coordinate design feasibility with manufacturing, and insure adequacy of product documentation. Direct product design modifications, incorporate design requirements, and harmonize state-of-the-art technology, manufacturability, cost effectiveness and quality requirements. Establish project schedules and hold design review meetings at appropriate intervals to insure satisfactory project performance. Provide technical support to operations in Mexico, Brazil and other Latin American countries. Requires a Bachelor's degree in Electrical Engineering, one year of experience in the job offered or one year of experience in the related occupation of Junior Engineer. Requires fluency in Spanish (oral and written) and experience with digital controllers, analog controllers, digital systems design and pasteurizers. M-F, 8-5, $667.00/week. Please send resume to: Ms. Pat Ganno, Job Order No. 0486629, Job Service of Florida, P.O. Box C, Clearwater, Florida 34618-4090.

Electronics Science and Technology Division. Electrical Engineer, GS-0850-12, $41,023 to $52,210 (salary dependent upon qualifications). The Electronics Science and Technology Division (ESTD), Naval Research Laboratory, invites applications for the position of Research Electrical Engineer in the Imaging Section of the Solid State Devices Branch. This Section carries out research into the physics of devices in narrow bandgap semiconductors in an effort to develop conceptually new and higher performance infrared detectors. The Section is seeking a candidate who has at minimum a Ph.D. in Electrical Engineering (or equivalent). Applicants must meet the following selective factor: Demonstrated ability to perform research in solid state physics relating to the properties of narrow bandgap semiconductor infrared devices including skill in the use of high magnetic field and far infrared apparatus in the characterization of semiconductor materials. Expertise in the physics of reduced dimensionality semiconductor systems (e.g. inversion layers) is also desired. The successful candidate should be able to use the expertise described above to advance the fundamental understanding of the performance of infrared detectors in novel infrared sensitive materials. Call for vacancy announcement and send application for Federal Employment (SF-171) postmarked by November 30, 1991 to: Naval Research Laboratory, Civilian Personnel Division, Attention 68-101B-89 (IS), 4555 Overlook Avenue, SW., Washington, DC 20375-5000. (202)767-3030. An Equal Opportunity Employer. US citizenship required.

Senior Device Engineer—Develop & maintain high-frequency S-parameter measurement and noise characterization systems; conduct HSPICE BiCMOS modeling, automatic data acquisition & parameter extraction, and electronic circuit simulation. Ph.D. in Electrical Engineering. Academic project/research background in high-frequency S-parameter measurement, noise measurement techniques and system development, BiCMOS transistor signal & noise characteristics/characterization, computer-controlled device characterization, electronic circuit simulation, BiCMOS device physics, noise mechanisms in devices, HSPICE, SPICE, and HP Spectrum analyzer; academic coursework in semiconductor device theory, semiconductor physics and electronic devices & circuits. $4,166.67/mo.; 40 hrs./wk. Place of employment and interview: San Jose, CA. If offered employment, must show legal right to work. Clip ad and send with resume to: Job No. MD21361, P.O. Box 9560, Sacramento, CA 95823-0560 not later than Nov. 30, 1991.

Scientist—Siemens Quantum, Inc., produces state-of-the-art diagnostic ultrasound equipment. We are currently seeking: Ultrasound Senior/Staff Scientists—Working in the Ultrasound Laboratory, you will contribute directly to new product and system design. You will also define performance requirements and perform analysis/system design of ultrasound imaging systems, develop new ultrasound signal processing concepts and coordinate the implementation of new concepts within the R&D organization. Senior Level requires 5 years', Staff level 8 years' ultrasound imaging experience. Digital Signal Processing Senior/Staff Scientists—Play ■ lead role in the advancement of digital signal processing sub-systems as you establish acceptable performance parameters. Your individual contribution to functional analysis and overall system design of these systems will be critical to project success. Additionally, you'll ■■■ your new concepts for digital signal processing through development and implementation in Research and Development. Senior Level requires 5 years', Staff Level ■ years' digital signal processing experience. All scientist positions require an MSEE (PhD preferred). Incumbents must be technical experts in system analysis and signal processing with a proven track record of technical achievements and contributions. Experience in commercial ultrasound imaging is ■ plus. We offer an excellent salary and benefits package. Please send your resume including salary history and/or requirements to: Personnel Director, Siemens Quantum, Inc., 2527 Camino Ramon, Suite 100, San Ramon, CA 94583. EOE, M/F/H/V.

Technically speaking

(Continued from p. 18)

lunatic fringe: *n.* Customers who can be relied upon to buy release 1.0 software.

mouse droppings: *n.* Pixels (usually single) that are not properly restored when the mouse pointer moves away from a particular location on the screen.

New Testament: *n.* The second edition of K&R's (Brian Kernighan and Dennis Ritchie's) *The C Programming Language* (Prentice-Hall, 1988), describing ANSI Standard C. The first edition is referred to as the **Old Testament**.

programming: *n.* 1. Classically, the art of debugging a blank sheet of paper (since the rise of on-line editing, probably to be recast as the art of debugging an empty source file). 2. A pastime akin to banging one's head against a wall, but less rewarding.

sneakernet: *n.* Term used for transfer of electronic information by physically carrying tape, disks, or some other media from one machine to another. Also called Tennis-Net, Armpit-Net, or Floppy-Net.

softy: *n.* Hardware hackers' term for a software expert ignorant of hardware.

spaghetti code: *n.* Code with a complex and tangled control structure, especially one using many GOTOs, exceptions, or other unstructured branching constructs.

spooge: /spooj/ *n.* Inexplicable or arcane code, or random and probably incorrect output from a computer program.

tense: *adj.* Of programs, very clever and efficient. Hence, a tense programmer is one who produces tense code.

troglodyte mode: *n.* Programming with the lights turned off, sunglasses on, and the terminal inverted (black on white) because you've been up for so many days straight that your eyes hurt.

vaporware: *n.* Products announced far in advance of any release (which may or may not actually take place).

vulcan nerve pinch: *n.* The keyboard combination that forces a soft-boot or jump to ROM monitor. On many micros this is Ctrl-Alt-Del; on Suns, L1-A; on some Macintoshes, it is <Cmd>-<Power switch>!

wave a dead chicken: *v.* Perform a ritual in the direction of crashed software or hardware that one believes is futile but necessary to assure others that effort has been expended. Also known as a rain dance.

wedged: *adj.* Stuck, incapable of proceeding without help (whereas crashing describes total nonfunctioning). The system may be capable of doing a few things, but is not fully operational.

WIMP environment: [acronym of Window, Icon, Menu, Pointing device] *n.* A graphical-user-interface–based environment, as described by a hacker who prefers command-line interfaces for their superior flexibility and extensibility. Macintoshes and Microsoft Windows use WIMP interfaces.

wizard: *n.* A person who knows how a complex piece of software or hardware works and can find and fix bugs quickly in an emergency. —*Kevin L. Self*

Kevin L. Self is a full-time design engineer for Texas Microsystems Inc., Houston, and part-time hacker. He also writes on science and technology issues for a number of publications.

Another misnomer: power supply

Last August's *Technically Speaking* column, "Too accurate?" [p. 11], which told how the formally correct "first transition duration" and "last transition duration" have never ousted "rise time" and "fall time," prompted Victor Wouk of New York City to write about the "power supply." Here, too, he observed, engineers prefer long-used and scientifically incorrect terms.

According to Wouk, the products of the power supply industry are not power *supplies*—that is, suppliers or, inferentially, sources of power. They are power *converters*: they convert electric power from the form in which it is available into the form in which it is required.

This improper nomenclature passed unnoticed until the advent of the Space Age—and a 1958 meeting of the executive committee of the Institute of Radio Engineers (IRE) standards-writing Professional Group on Power Supplies. At that meeting, Wouk recalled, the late Francisz Schwarz, a pioneer in resonant switching regulators, grew huffy. Involved in the problems of solar panels and other electricity sources for operating equipment on satellites, he insisted (properly) that the solar panels were the power *supplies*, and the systems changing the erratic dc supply into well-behaved ac or dc, were the power *conditioners*.

The term *power converter* was not acceptable, Wouk continued, because decades before it had been preempted by the power industry. That industry used *rotary converter* for a machine that converts ac to dc without rectifiers. So, *power conditioner* was the practical choice, and was standardized by the IRE committee.

Guess what? *Power supply* remained in use. The term originated in the early days of radio, Wouk noted. Some early radios relied on rechargeable *batteries* to provide the A voltage for the vacuum tube filament; B for the plate-cathode; and C for the grid bias. These were indeed the *power supplies*.

Along came rectifiers and the "plate transformer" that could change the household voltage (if it was ac) into the A, B, and C voltages. No batteries! So, *power supply replacements* came into being, and were sold as such starting in the late 1920s. The *replacements* soon was dropped, and, said Wouk, there remained *power supply*.

COORDINATOR: Alfred Rosenblatt
CONSULTANT: Anne Eisenberg, Polytechnic University

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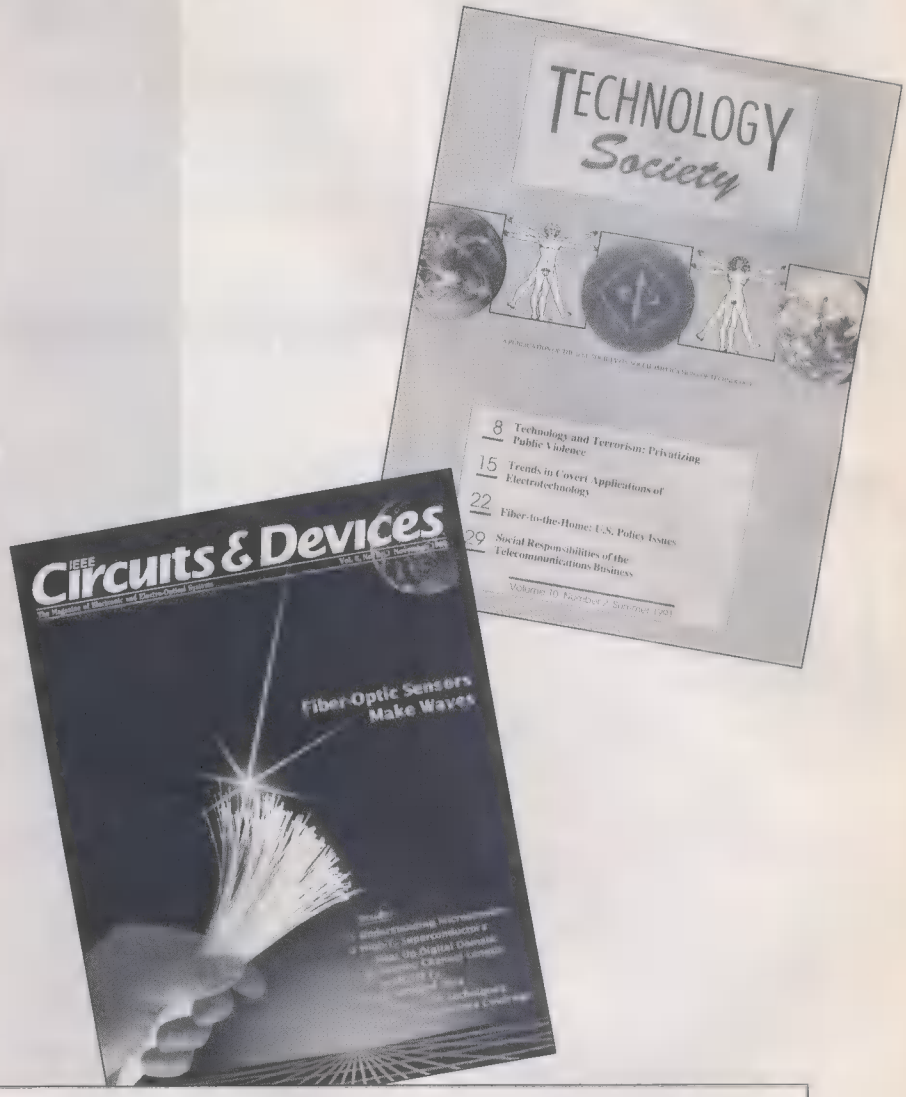

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Scanning
The Institute

THE INSTITUTE *reinstated*

At its September meeting, the IEEE Executive Committee approved the publication of one more issue of THE INSTITUTE in 1991. A November-December issue will be mailed in mid-November and will contain, among other information, the IEEE election results.

Bromley honored by IEEE-USA

D. Allan Bromley, assistant to the President for science and technology, was recognized for distinguished public service by the IEEE's United States Activities unit at the latter's annual meeting in September. Bromley was cited by IEEE-USA board chairman Michael J. Whitelaw for "his outstanding contributions to the development and implementation of Federal policy on science, engineering, and technology." Bromley was scheduled to receive his award in Washington, D.C., on Oct. 23.

Among numerous other awards announced at its meeting, IEEE-USA named three people for its Award for Literary Contributions Furthering Public Understanding of the Engineering Profession:

- Eleanor R. Adair (SM) of Yale University, New Haven, Conn., for "her scholarly and balanced paper titled 'Currents of Death Rectified,' " responding to a series of articles on the health effects of electric and magnetic fields appearing in *The New Yorker.*
- Richard Harris of National Public Radio for "his balanced five-part series on magnetic fields."
- Robert K. Bellinger of *Electronic Engineering Times* for "his continued objective and unbiased research and reporting of information on professional activities for the profession."

Membership up

Institute membership in August totaled 299 886, an increase of 1402 or 0.5 percent since August 1990. U.S. members currently constitute 76.2 percent of total membership, but the percentage of non-U.S. members has been increasing for several years.

Teleconferencing use promoted

To cut back on travel and other expenses for staff and volunteer committee meetings, the IEEE is encouraging the use of teleconferencing. The IEEE facilities in New York City, Piscataway, N.J., and Washington, D.C., provide teleconferencing capabilities for conducting off-site meetings.

To arrange for conference rooms and teleconferencing, contact the following: in New York City, Valorie White, 212-705-7900; in Piscataway, Lorraine Nero, 908-562-5403; in Washington, Arnette Riddick, 202-785-0017. Easels, flip charts, overhead projectors, and other such equipment are available and may be reserved when meetings are set up. Food service is obtainable at cost.

How to keep up with LAN/MAN standards

A new IEEE service helps users stay abreast of local- and metropolitan-area network (LAN/MAN) standards. Developed for the organizations or individuals who must have the most current versions of these documents, the service provides the subscriber with one copy of each newly approved standard as soon as it becomes available and at a 40 percent discount.

For a brochure, write or call IEEE Standards, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3800.

IEEE Proceedings *revamped*

The made-over *Proceedings of the IEEE* should be more useful for the specialist and more accessible to the nonspecialist, as well as more affordable for libraries.

The changes made include:

- A broader range of subjects, extending from timely technical areas to engineering management and history.
- A one-page prolog to each article relating its contents to the day-to-day projects of an engineer.
- Use of two categories of tutorial papers—"career boosters," dealing with fundamentals, and "curiosity satisfiers," presenting overviews.
- An expanded book reviews section.
- Addition of a two-year subscription rate with a 5 percent discount for libraries.

Coming
in Spectrum

Extraordinary careers. A few exceptional engineers and scientists, little known outside their specialties, have adapted continually to rapidly changing technology. This article describes the careers and contributions of several such innovative geniuses and examines what they have in common.

Posix for portability. Portable, standard components for application software will at last be possible to write with the aid of the open systems interface standards in the IEEE Posix Open Systems Environment. Posix stands for portable operating system interface X, with the X denoting its Unix origin.

Service awards, prize papers. In 1991, one company and over a half-dozen people involved in a variety of electrical engineering disciplines earned recognition from the IEEE for papers written, engineering leadership, or corporate innovation.

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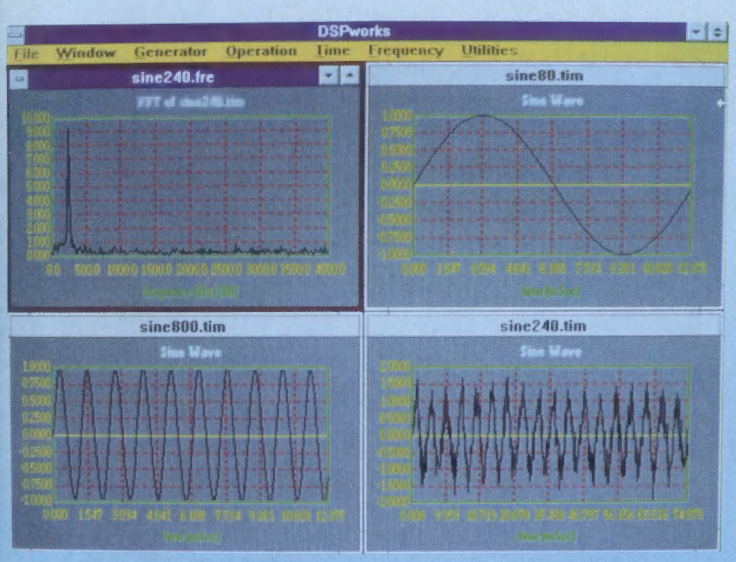

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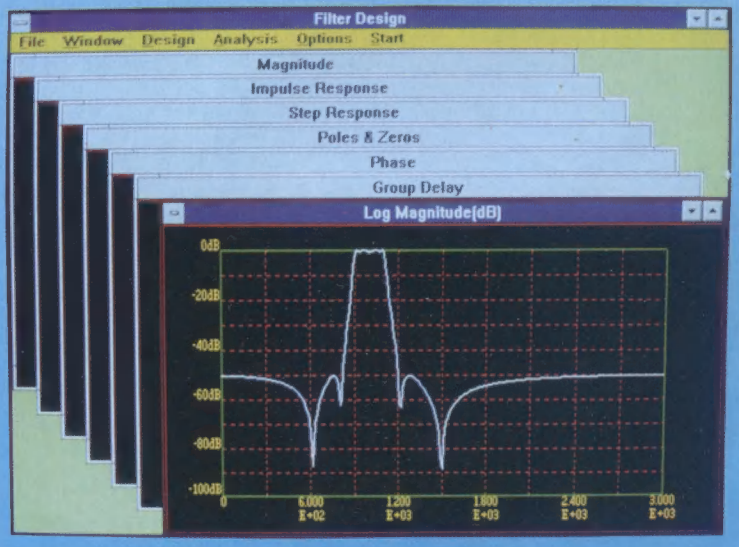

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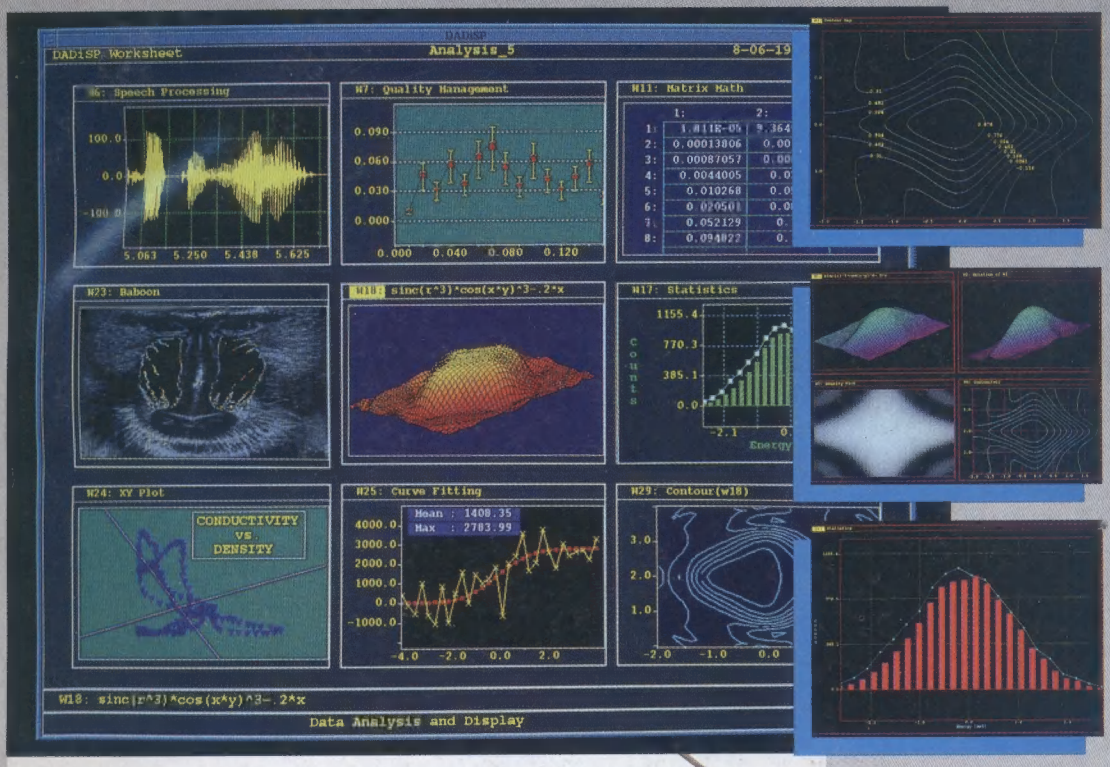

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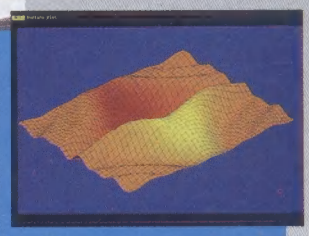

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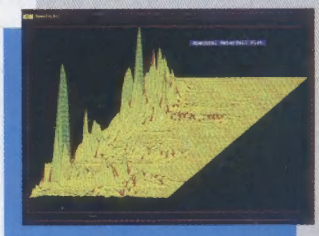

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